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CAUSAL EFFECTS OF PETROCARIBE ON SUSTAINABLE DEVELOPMENT: A SYNTHETIC CONTROL ANALYSIS*

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We examine the causal effects of the energy subsidy programme PetroCaribe in the three dimensions of sustainable development: economic, social and environmental. We use the synthetic control method to construct a counterfactual and compare it to the outcomes of the beneficiary countries and thus estimate the magnitude and direction of the PetroCaribe effect. PetroCaribe had a positive effect on economic growth in most of the beneficiary countries; however, this economic boost was not followed by an improvement in social development. Environmentally, PetroCaribe did not negatively or positively impact the environmental quality of the member countries, in the sense that we do not find a significant effect on the trend of CO_2 emissions per capita.

1 Introduction

The PetroCaribe programme, initiated by the late President Chavez of Venezuela, sold oil below market price to political allies. This paper is the first to study the implications for the beneficiaries on their economic growth, energy use, and societies.

Oil prices exhibited unprecedented volatility at the beginning of the 2000s, with an upward trend during 2003-2008. Prices rose from US$30 in 2003 to a historic high of US$147 in 2008. Overall, the extent of the adverse effects of high and volatile oil prices depend on whether a country is an oil exporter or importer, its level of development and on the governmental capability to face oil shocks (Monaldi, 2015; Yépez-García and Dana, 2012). In particular, in oil importing countries that are highly reliant on oil for

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power generation, the steep rise in the world oil price posed challenges to the government, which had to take action through a variety of policy interventions to mitigate the negative effects to their macroeconomic variables, such as subsidies.[1]

In Latin America and the Caribbean, specifically in Central America and the Caribbean region, all countries except for Trinidad and Tobago and Guatemala are net oil importers and nearly 81 percent of their electricity supply comes from oil products, which makes the region highly vulnerable to oil price fluctuations.

Amid the peak of high oil prices in mid-2000, Venezuela, together with several countries in Central America and the Caribbean, founded the PetroCaribe Energy Cooperation Agreement. Initially signed by 14 countries in June 2005, PetroCaribe currently has 19 members. The agreement provides a financial subsidy that allows its members to buy Venezuelan oil and oil products at concessionary prices, or to exchange it for goods and services not produced in Venezuela. The stated main objective of the agreement is to contribute to the energy security, socioeconomic development and the integration of the Caribbean countries through the sovereign use of their energy resources. Along with supply, PetroCaribe also aims to finance energy infrastructure and development of indigenous, alternative energy sources. The IMF estimates the size of the PetroCaribe subsidy at least 0.7 per cent of GDP of the beneficiaries on average in 2015 (McIntyre *et al.*, 2016). The savings derived from the oil bill are used at the beneficiaries' free will. Some countries have used part of the funds to locally subsidize energy and transport (Di Bella *et al.*, 2015; ECCB, 2015; Niel *et al.*, 2014). This and other types of energy subsidies are a common response of governments to cope with high fuel prices. Its use has been linked to supporting energy security, domestic energy production and affordable access to energy, which are expected to have wider positive effects on economic and social development (Bacon and Kojima, 2006; Whitley and Van Der Burg, 2015).

Yet, regardless of intentions, in recent years fossil fuel subsidies, including those by PetroCaribe, have been put under scrutiny. When the full economic, social and environmental costs and benefits of fossil fuel subsidies are taken into account, their net costs have often been found to outweigh the benefits of sustaining them (UNEP, 2008; Whitley and Van Der Burg, 2015). It is argued that subsidies can inhibit economic development, drain public finances and reduce funds available for addressing social and development objectives. From an environmental perspective, subsidies increase the consumption of fossil fuels, thus exacerbating their negative effects on the environment by increasing greenhouse gas emissions. Moreover, energy subsidies impose barriers to the adoption of energy efficiency measures and

[1]We adopt the OECD definition of energy subsidy as 'any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers or producers' (OECD, 2005, p. 114).

renewable sources of energy (Bridle and Kitson, 2014; UNEP, 2008). Their implication for sustainable development and climate change has led to calls for phasing out those subsidies from international organizations, such as the G20 in 2009, the Asian-Pacific Economic Cooperation in 2010 and the United Nations' Rio+20 Summit in 2012 (Oosterhuis and Umpfenbach, 2014). International organizations, such as the Organization for Economic Co-operation and Development (Burniaux and Chateau, 2014), the International Monetary Fund (Coady *et al*., 2015), and the International Energy Agency IEA (2015a) have substantiated the rationale of these calls for a phase-out by research.

Studies on the estimated scale of fossil fuel subsidies are traditionally measured using a price-gap approach, based on the differential between the end user price of fossil fuel and a reference price, e.g. international fuel prices. However, most of the times, the data used to construct such estimates is lacking, and therefore has to be estimated. Moreover, the method cannot capture government interventions that support industries or individuals but do not affect the final price of the good (Stefanski, 2016). Other economic models that have been used are simple models of fuel demand (IEA, 2015b) or more advanced CGE models (e.g. Acar and Yeldan, 2016; Lin and Ouyang, 2014). Therefore, the estimated effects of fuel subsidies on the economy, the environment, and indicators of social development, have been modeled and are, strictly speaking, not estimated on the basis of observable data. This is a weak basis for estimating the impact of subsidies.

In contrast, to overcome the aforementioned lack of appropriate estimation methods, in this paper, we propose to estimate the effect of an energy subsidy within an impact evaluation approach. In order to do so, we apply the synthetic control method (SCM) (Abadie and Gardeazabal, 2003; Abadie *et al*., 2010), a data-driven method that construct a *synthetic* country as a weighted combination of weighted control countries.

Since energy has a critical role in economic and social development, energy subsidies need to be analyzed in the context of sustainability (OPEC, 2010). In this sense, PetroCaribe offers an interesting setting to analyze a certain type of energy subsidy, since its objectives are easily identified with the so-called three pillars of sustainable development—economic, social and environmental. Therefore in this research, we empirically analyze the effect of PetroCaribe on the following outcomes: economic development, represented by GDP per capita; social development, represented by the Human Development Index; and the environment, represented by per capita CO_2 emissions along with electricity use.

This paper fills a methodological gap in the energy subsidies literature and sheds light on the causal effects of PetroCaribe's subsidies on sustainable development. To the extent of our knowledge, this is the first study that applies an impact evaluation technique for the analysis of energy subsidies, as well as for the analysis of PetroCaribe.

With the SCM, we are able to estimate what would have been the evolution of our outcomes of interest if countries had not joined PetroCaribe. Our main results suggest that PetroCaribe does not represent a contradiction with the discourse of sustainable development. Overall, PetroCaribe members experienced an improvement in economic development without a deterioration of their environment. Although the countries have a growing trend in their per capita CO_2 emissions, our analysis concludes that this was not significantly different from what they would have experienced without the intervention. However, the positive results in economic growth were not reflected in an improvement of social development.

The rest of the paper is organized as follows. Section 2 outlines the PetroCaribe Energy Cooperation Agreement and the signatory countries. Section 3 presents the synthetic control method. Section 4 presents the data and specification. The results are described in Section 5, while Section 6 discusses the findings and concludes.

2 The PetroCaribe Energy Cooperation Agreement

PetroCaribe is an energy cooperation agreement between Venezuela and 18 Central America and Caribbean countries: Antigua and Barbuda, the Bahamas, Belize, Cuba, Dominica, Grenada, Guyana, Jamaica, the Dominican Republic, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname, Haiti, Nicaragua, Honduras, Guatemala and El Salvador.[2] Launched in 2005,[3] the agreement provides Venezuelan oil to the member countries at highly concessionary terms.

The stated objectives of PetroCaribe go beyond the oil supply. It seeks to be a mechanism that ensures that the savings derived from the energy

[2]Despite joining PetroCaribe, the Bahamas, Guatemala and St. Lucia did not enter into bilateral agreements.

[3]The antecedents of PetroCaribe are: The Puerto Ordaz Accord, signed in 1974 between several Caribbean countries, Central American countries and Venezuela. The aim of the arrangement was to ease the foreign exchange and balance-of-payment problem suffered by oil-importing countries as a result of higher oil prices. The financing scheme established a reference price of $6 per barrel (December 1973 price of Venezuelan oil) to be paid to Venezuela; the difference between this reference price and the current international price was deposited in local currency in the importer's central bank. The agreement expired on December 31, 1980 (Grayson, 1988; Mayobre, 2005). The San Jose Accord (The Program for Energy Cooperation with the Countries of Central America and the Caribbean) was signed in 1980 by Mexico and Venezuela, under the agreement both countries were supposed to supply 160,000 barrels per day (bpd) of crude oil (80,000 each one) to 11 Central American and Caribbean countries at a discounted price. Since its creation, the agreement was renovated until 2007. Finally, The Caracas Energy Cooperation Agreement, signed in 2000 was intended to expand the San Jose agreement and include Cuba and other small countries of the Antilles, but it did not prosper (Ruiz, 2010).

bill are allocated to economic and social development programs. It also contemplates energy-saving programs and the development of alternative sources of energy energy (Petrocaribe, 2005; SELA, 2013).

The financing scheme establishes that the signatory countries can buy oil from Venezuela at market prices (as a member of the OPEC, Venezuela cannot sell below global market prices) but receive financing in the form of a soft loan. The percentage of the financed oil bill fluctuates with the international oil prices. When the price is equal to or below US$40, up to 30 percent of the bill will be financed by a 15-year loan plus two years of grace at 2 per cent interest. When the price of the barrel exceeds US$40 and the deferred financing part ranges between 40 to 70 percent, the payment is extended to 25 years, with two years of grace period at 1 per cent interest. The agreement also stipulates that part of the debt can be paid through a trade compensation mechanism, that is, countries can pay back up to 50 percent of their debt with goods and services. To cite some concrete examples of payments by the trade compensation mechanism, Guyana signed a rice-for-oil agreement; Nicaragua trades diary products, sugar, oil and beans seeds; the Dominican Republic pays back the bill with sugar and peas and Jamaica sends clinker to Venezuela (Jácome, 2011).

Although Cuba is technically a PetroCaribe member, the energy relationship between Cuba and Venezuela is handled under the terms a different agreement. Cuba and Venezuela signed, in October 2000, the Integral Cooperation Agreement (CIC), under which Venezuela supplied at a preferential price (US$27) 53,000 barrels per day. The daily quota increased in 2005 up to 98mbd, on average receives 72.7 mbd (PDVSA, 2014). Half of the oil bill is to be paid within 90 days after the purchase and the rest over 25 years, with a 2-year grace period, including the cost of transportation and insurance. In exchange, Cuba pays back part of its debt with medical services, sports trainers, consultants and military advisors (Romero, 2010).

Oil quotas are country-specific, defined in a bilateral market agreement with Petroleos Venezuela (PDVSA). As can be seen in Table 1, no country receives the amount of oil agreed.

Although there are other countries that take part in similar bilateral agreements (e.g. Jordan signed an agreement in 2008 effective for three years, whereby it can buy Iraqi crude at a concessionary price of $22 per barrel. Iran agreed to a deferred payment arrangement with Pakistan in which the credit facility for payment was extended from 30 to 90 days Kojima, 2009), none has been of the duration or scope of PetroCaribe.

The academic literature on the effects of PetroCaribe in its member countries is scarce and mostly focused on a political analysis (Jácome, 2011; Koivumaeki and Rodrígues, 2014; López and Villani, 2014; Morales Manzur *et al.*, 2010). Some authors underline positive results of the Agreement. It has been argued that PetroCaribe has had a significant impact on helping member countries deal with the rise in crude oil and food prices. Without the subsidy, the rising costs would have meant a catastrophe for many countries, especially in those with high poverty rates and energy deficit (Benzi and Zapata, 2012; Trinkunas, 2014).

Sardinas *et al.* (2009) highlight the positive impact on the urban development of the Cuban city of Cienfuegos as a result of the improved performance of the Camilo Cienfuegos refinery, a PetroCaribe project focused on infrastructure investment. However, the energy agreement is subject to the same criticisms, in general, of energy subsidies. For some authors, PetroCaribe represents an uneconomical energy practice with limited social and economic benefits and rather an increased debt for the participating countries. The high dependence on a single source of subsidized oil, has sustained the dependence on fuel for power generation, discouraging the transition to alternative, more efficient and less expensive feedstock for electricity. Environmentally, the discouragement in the investment of renewable sources exacerbates the use of fossil fuels, jeopardizing the regional efforts to reduce carbon dioxide emissions (Di Bella *et al.*, 2015; Goldwyn and Gill, 2014; Johnston, 2014; Lacayo, 2013).

Table 1
Real And Accrued Supplies, And Quotas

		2014		*2005–2014*
		Average 2014	*Quota Fulfillment*	*Supplies*
Country	*Quota*	*MBD (thousands of barrels per day)*	*%*	*MMBIs*
The Dominican Republic	30	10.1	34	91.1
Jamaica	23.5	22.3	95	83.5
Nicaragua	27	22.3	83	64.3
Haiti	14	15.2	109	32.6
Guyana	5.2	4.1	79	11.5
Antigua and Barbuda	4.4	0.7	16	2.9
Grenada	1	0.5	50	2
St.Kitts and Nevis	1.2	0.7	58	1.8
Dominica	1	0.2	20	1
St. Vincent and the Grenadines	1	0.5	50	0.9
Belize	4	3.2	80	2.9
Suriname	10	1.4	14	3.2
El Salvador	7	6.5	93	15
Total PetroCaribe	129.3	87.7	68	313
Cuba	98	72.7	74	2

Source: (PDVSA, 2014, 2015).

3 Methodology

As mentioned in Section 1, we evaluate the impact of PetroCaribe. Impact evaluation techniques compare outcomes for treated unit with counterfactual baselines to estimate what would have happened without an intervention. The counterfactual is never observed but is estimated using outcomes in similar units, with similar characteristics. A common strategy to estimate such interventions is the difference-in-differences model (DiD). The DiD compares the difference before and after the intervention in the outcome of a treated unit and the control group to determine the net impact. However, the main drawback of the DiD is its key assumption of parallel trends, i.e. it is assumed that in the absence of the intervention, the treatment and control group would have had the same trend across time. To overcome the aforementioned issue, we use the synthetic control method (SCM) developed by Abadie and Gardeazabal (2003) and further developed by Abadie et al. (2010, 2015). The SCM relaxes the parallel trend assumption and constructs a synthetic control match for the treated unit by using untreated units in the control group in such a way that the synthetic counterfactual has a similar behavior to the actual treated unit before the intervention.

Since the pioneering work of Abadie and Gardeazabal (2003) who use this approach to analyze the economic effect of terrorism in the Basque country, the SCM has been used in economics and other social science to analyze a wide range of interventions. For example, Abadie *et al.* (2010), study the effects of a tobacco prevention legislation in California in 1988 on tobacco consumption. Hope (2016) investigates the effect of the Economic Monetary Union on the account balance. Billmeier and Nannicini (2013) estimate the effect of trade liberalization on economic growth. Sills *et al.* (2015) employ this method in investigating the impact of a local policy initiative to limit deforestation in the Brazilian Amazon. Grier and Maynard (2016) evaluate the impact of the president Hugo Chavez on the Venezuelan economy.

Following Abadie and Gardeazabal (2003) and Abadie *et al.* (2010, 2015), let us assume that we observe countries $i = 1, \ldots, N + J$. Countries 1 to N are exposed to the intervention (here, are signatories of the PetroCaribe programme) at time $\left[T_0 + 1\right]$ and the remaining J countries form the donor pool from which the synthetic control countries are created. Let Y_{it}^{PC} be the outcome variable observed for country i, member of PetroCaribe (PC) at time t. Similarly, let Y_{it}^{NP} be the outcome variable observed for country i, not member of PetroCaribe (NP), at time t.

The outcome variable for any country i at time t can be written as:

$$Y_{it} = Y_{it}^{NP} + \alpha_{it} S_{it}. \tag{1}$$

where α_{it} is the effect of the intervention for country i at time t, and S_{it} is a binary indicator variable that takes the value one if the intervention has taken place and value zero otherwise.

Assuming a single signatory (i.e. $N = 1$), the effect of PetroCaribe for country 1 (i.e. $i = 1$ and $t \geq T_0$) in equation (1) can be defined as:

$$\alpha_{1t} = Y_{1t}^{PC} - Y_{1t}^{NP}. \tag{2}$$

In equation (2) the only observed variable is Y_{1t}^{PC}, hence the counterfactual Y_{1t}^{NP} can be estimated as follows:

$$Y_{1t}^{NP} = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it}, \tag{3}$$

where δ_t is a vector of common time-specific factors constant across countries; θ_t is a vector of unknown parameters; Z_i is a $(r \times 1)$ vector of observed covariates not affected by the intervention, which can be either time-invariant or time-varying; λ_t is a $(1 \times F)$ vector of unobserved common factors, μ_i is a $(F \times 1)$ vector of unknown unit specific factors, and ε_{it} are idiosyncratic error terms with zero mean.

Let us define a synthetic control unit as a weighted average of countries in the donor pool. That is, it can be represented by a $(J \times 1)$ vector of weights $W = \left(w_2, \ldots, w_{J+1}\right)'$ such that $w_j \geq 0$ for $j = 2, \ldots, J+1$ and $\sum_{j=2}^{J+1} w_j = 1$. Each value of the vector W represents a potential synthetic control for a PetroCaribe country, for which its outcome variable is defined by:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_j + \lambda_t \sum_{j=2}^{J+1} w_j \mu_j + \sum_{j=2}^{J+1} w_j \varepsilon_{jt}. \tag{4}$$

Suppose there is a vector of weights $\left(w_2^*, \ldots, w_{J+1}^*\right)'$ such that:

$$Y_{1t} = \sum_{j=2}^{J+1} w_j^* Y_{jt}, \quad \forall t \in \{1, \ldots, T_0\} \text{ and } Z_1 = \sum_{j=2}^{J+1} w_j^* z_j \text{ holds,} \tag{5}$$

i.e. the weighted average of the pre-treatment outcomes of the control perfectly matches the pre-treatment outcomes of the treated country and the weighted average of the covariates of the control perfectly replicates the covariates of the treated country. Then, the estimated treatment effect for the treated country can be estimated as:

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{it}, \quad \forall t \in \{T_0 + 1, \ldots, T\}. \tag{6}$$

Conditions in equation (5) hold exactly only if $\left(Y_{1t}, Z_1\right)$ belongs to the convex hull of $\left[\left(Y_{21}, \ldots, Y_{2T_0}, Z_2'\right), \ldots, \left(Y_{J+11}, \ldots, Y_{J+1T_0}, Z_{J+1}'\right)\right]$, i.e.

there should exist some combination of untreated units that exactly match the treated country before the treatment. Usually, is not possible to estimate a perfect synthetic control because there are no weights w_j^* for condition (5) to hold exactly. Thus, in practice, W^* is estimated in a non-parametric fashion and is selected such that (5) holds approximately. W^* is selected by minimizing the distance between the vector of characteristics (covariates and pre-treatment outcomes) of the signatory countries (X_1) and the weighted matrix that contains the same characteristics of each potential donor pool ($X_0 W$) in the pre-treatment period.

Formally, let the vector $K = \left(k_1, \ldots, k_{T_0}\right)'$ define a linear combination of pre-treatment outcomes $\overline{Y}_j^K = \sum_{s=1}^{T_0} k_s Y_{js} \quad \forall j \in \{1, \ldots, J+1\}$. Let us consider N of such linear combinations be define by the vectors $\left(K_1, \ldots, K_N\right)$. X_1 is a $(k \times 1)$ vector defined as: $X_1 = \left(Z_1', \overline{Y}_1^{K_1}, \ldots, \overline{Y}_1^{K_N}\right)$ containing k covariates and pre-treatment outcomes of the signatory country. Similarly, X_0 is a $(k \times J)$ matrix that contains the same variables for each country in the donor pool. The differences between the pre-treatment characteristic of the PetroCaribe countries and a synthetic control is given by the vector $\|X_1 - X_0 W\|$. The vector W^* is chosen so that it minimizes:

$$\|X_1 - X_0 W\|_V = \sqrt{\left(X_1 - X_0 W\right)' V \left(X_1 - X_0 W\right)} \tag{7}$$

where W is a weighting vector that measures the relative importance of each control country in the construction of the synthetic control, and V is a $(k \times k)$ symmetric and positive definite diagonal matrix that reflects the relative importance of each covariate and pre-treatment outcome. The choice of V influences the root mean square error of the estimator (RMSPE). Abadie and Gardeazabal (2003) suggest to choose a V such that the RMSPE of the outcome variable is minimized for the pre-intervention period:

$$RMSPE = \sqrt{\frac{1}{T_0} \sum_{1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \right)^2}. \tag{8}$$

While the choice of the covariates Z_i can be justified by selecting those variables that better explain the outcome variable, there is no consensus on the optimal set of pre-treatment outcomes ($\overline{Y}_j^K$) that need to be included as predictors. Abadie *et al.* (2010) suggest as an obvious solution to use the values of the outcome variable for all the pre-treatment years, Bohn *et al.* (2014), Gobillon and Magnac (2016) use this approach. However, Kaul *et al.* (2017) show that including all pre-treatment outcomes as predictor leads to all other predictors receiving zero weights. Another very common specification is to use the average of the pre-treatment outcome, Abadie and Gardeazabal (2003), Abadie *et al.* (2015), Kleven *et al.* (2013) among others, perform their analysis with this linear combination. Bove *et al.* (2014) select four out of ten pre-treatment period to analyze the impact of civil war on GDP. Montalvo (2011) uses only the last two pre-treatment values.

Based on the previous discussion, we test five different placebo specifications that differ only in the linear combination of lagged outcome variable used as predictor. For each specification, we compute the SCM on each country j in the donor pool as treated[4]:

1. The average of all pre-treatment outcomes: $X_j = \left[\frac{\sum_{t=1}^{T_0} Y_{j,t}}{T_0}\right]$.
2. The last pre-intervention period: $X_j = \left[Y_{j,T_0}\right]$.
3. The first and last period of the pre-treatment: $X_j = \left[Y_{j,1}, Y_{j,T_0}\right]$.
4. The first, half and last period of the pre-treatment: $X_j = \left[Y_{j,1}, Y_{j,\frac{T_0}{2}}), Y_{j,T_0}\right]$.
5. The first, two half and last two periods: $X_j = \left[Y_{j,1}, Y_{j,\frac{T_0}{2}}, Y_{j,\frac{T_0}{2}+1}, Y_{j,T_0-1}, Y_{j,T_0}\right]$.

We calculate the post-treatment RMSPE of each specification. As suggested by Ferman *et al.* (2016), since the control countries did not experience the intervention, we ideal specification will be the one with the lowest RMSPE in the post-treatment period:

$$min_{s\in S}\left[\frac{1}{(T-T_0)J}\sum_{j=2}^{J+1}\sum_{t=T_0+1}^{T}\left(Y_{j,t}-\hat{Y}_{j,t}^{s}\right)^2\right]. \tag{9}$$

Once the proper specification is selected, it is vital that the weighted synthetic outcomes match the outcomes for the treated country in the pre-treatment period. To assess whether the synthetic country is a good counterfactual, we estimate the R^2 statistic, the coefficient of determinatin or the fraction of variance explained. This is essentially one minus the pre-treatment MSE normalized by the variance of the treated country:

$$R^2 = 1-\frac{MSE}{\sigma_1^2} = 1-\frac{\sum_{t=1}^{T_0}\left(y_{1t}-\hat{y}_{it}\right)^2}{\sum_{t=1}^{T_0}\left(y_{1t}-\bar{y}_1\right)^2}. \tag{10}$$

R^2 can range from minus infinite to 1. An R^2 of 1 indicates a perfect match. If $R^2 = 0$ then the estimated synthetic is no more accurate than the average of the observed data, and a negative R^2 occurs when the mean of the observed data is a better counterfactual than the estimated synthetic control. Best fit is a matter of judgment (Sills *et al.*, 2015) that in this case hinges on the outcome of interest.

[4]As explained is Section 3, we construct country-specific donor pool for each PetroCaribe country and its outcome of interest.Thus, specifications (iv) and (v) vary from country to country depending on the outcome and donor pool.

To assess statistical significance, we conduct a series of placebo tests closely following Abadie *et al.* (2015). The first placebo test, known as in-space placebo, consists in iteratively applying the SCM on each country of the donor pool as if it was treated. Since the control country did not receive any intervention, we should not expect a treatment effect. If the placebo studies exhibits a treatment effect of similar magnitude to the one estimated for the actual treated country, we conclude that this treatment effect is driven entirely by chance and that the analysis does not provide a convincing evidence of a treatment effect.

However, we take into consideration that some control countries in the placebo experiments can have a bad pre-treatment fit with the consequent large RMSPE, casting doubt on their reliability. In order to avoid misleading conclusions, we drop placebo runs with a pre-treatment RMSPEs that are at last 1.5 times higher than that of the PetroCaribe country.

Since this visual analysis involves some amount of subjectivity, we additionally estimate the post-treatment RMSPE to the pre-treatment RMSPE ratios:

$$ratio_i = \frac{\sqrt{\frac{1}{T-T_0}\sum_{t=T_0+1}^{T}\left[y_{it}-\sum_{j\neq i}\widehat{w}_i^j y_{jt}\right]^2}}{\sqrt{\frac{1}{T_0}\sum_{t=1}^{T_0}\left[y_{it}-\sum_{j\neq i}\widehat{w}_i^j y_{jt}\right]^2}}. \tag{11}$$

This scale-free measure allows to estimate the extremity of the impact of the placebo experiments. The empirical distribution of the ratios allows to compute pseudo p-values as follows:

$$p\text{-value} = Pr\left(\widehat{\beta}^{SC} > \widehat{\beta}^{PC}\right) = \frac{1}{J+1}\sum_{i=1}^{J+1} I\left(\widehat{\beta}_{iT}^{SC} \geq \widehat{\beta}_{1T}^{PC}\right). \tag{12}$$

The pseudo p-values constructed in this context imply that if the treatment were to be assigned at random, then the probability of getting a ratio at least as large as the one estimated for the PetroCaribe country is $1/J+1$ (Abadie *et al.*, 2010). Note that the pseudo p-values necessarily depend on the number of control countries, meaning that some values cannot be significant at conventional levels (one-tailed test), which does not imply the absence of an effect.

As a second validation check, we test the sensitivity of the baseline model to the countries in the control pool. The so-called leave-one-out test consists in iteratively apply the baseline SCM omitting in each iteration one of the countries that received a positive weight in the baseline specification.[5]

[5]Countries that received zero weight do not change the results of the baseline model.

TABLE 2
LIST OF COVARIATES

Economic growth	*Social development*	CO_2 *emissions*	*Electricity use*
Lags of GDP	Lags of HDI	Lags of CO_2	Lags of electricity use
Industry share	GDP per capita	GDP per capita	GDP per capita
Services share	Access electricity	Trade openness	Urban population
Agriculture share	Internet	Urban population	Population density
School enrollment	Urban population	Industry share	Industry share
Internet		Services share	Services share
Urban population		Agriculture share	Inflation
Inflation			

This allows assessing whether one of the control countries is driving the results. If the synthetic control follows a similar trajectory, then it is less likely that the results are biased to the inclusion of any single control country.

4 Data And Specification

The analysis focuses on the effect of PetroCaribe on four outcomes of interest: (i) economic development, represented by GDP per capita; (ii) social development, represented by the Human Development Index; (iii) CO_2 per capita emissions; and iv) electricity use per capita . For covariates, we include the lags of the outcome variable and a set of standard predictors with a stable relationship with the outcome variable. These variables, displayed in Table 2, were selected by their predictive power based on empirical literature (Abadie and Gardeazabal, 2003; Almer and Winkler, 2012; Eren *et al*., 2014; Larivière and Lafrance, 1999) and availability. The period under consideration for economic growth and social development is 1990 to 2014, while for per capita CO_2 emissions and electricity use is 1980 to 2013. Descriptive statistics are shown in Appendix C. Sources and definitions are provided in Appendix G.

4.1 Treated Countries And Donor Pool

Although PetroCaribe officially has 18 members, three countries, the Bahamas, Guatemala and St. Lucia never entered into a bilateral agreement and are thus omitted from the analysis. For the remaining countries, we impose the following conditions: (i) the treatment needs to be sustained through a significant period, otherwise, if the post-treatment period is short, the SCM cannot estimate any real treatment effect. Four countries do not meet this condition. Belize and Honduras had interruptions in their supply.[6] Suriname and El Salvador joined at a later date, 2012 and 2014

[6]Belize stopped importing oil in 2009 (Mencias, 2016). Venezuela suspended the agreement with Honduras in June 2009 following the coup d'etat against then president Manuel Zelaya.

Table 3
Treatment Date

Country	*Signed*	*Treatment date*	*Country*	*Signed*	*Treatment date*
Antigua and Barbuda	2005	2006	Jamaica	2005	2005
Cuba	2000	2002	Nicaragua	2007	2007
Dominica	2005	2006	Dominican Republic	2005	2005
Grenada	2005	2007	St. Vincent and the Grenadines	2005	2005
Guyana	2005	2007	St.Kitts and Nevis	2005	2008
Haiti	2007	2007			

Source: ECCB (2015), GRENLEC (2007), Guyana Embassy, López and Villani (2014), Romero (2010), SELA (2013), WikiLeaks (2006).

respectively. (ii) The treated country cannot be an outlier in the dataset. Recalling that countries with extreme values of observed characteristics are unlikely to satisfy condition (5) in Section 2, in such case, the SCM cannot give a correct prediction. In this regard, Haiti was excluded. Being the poorest country in Latin America and the Caribbean, and one of the poorest in the world, US$1,737 in 2014, its outcomes of interest lie in the extremes, which make it difficult to build a donor pool with countries of similar characteristics. (iii) Countries do not have to be exposed to other significant shocks during the treatment period. Two countries do not satisfy this condition. Haiti suffered losses equivalent to 113 per cent of GDP as a result of an earthquake that struck the country in 2010 (ECLAC, 2014), three years after joining PetroCaribe. In Jamaica, high fluctuation in its GDP, CO_2 emissions and energy consumption are a major results of the closure of three of four bauxite and alumina plants in 2008; bauxite industry is the largest contributor to its GDP.

Regarding the treatment date, for some beneficiaries the delivery of oil was not made immediately after the signing of the agreement, but it was delayed a few years. Therefore, the treatment date is established as the year in which the countries received the first cargo of oil. Table 3 shows the treatment date considered in the analysis.

Taking into consideration the heterogeneous characteristics of the PetroCaribe beneficiaries, we build a country-specific donor pool for each outcome of interest. The potential donor pool is restricted to the following conditions: (i) the countries need to remain unexposed to the intervention through the period under study; (ii) to avoid interpolation bias, which might occur by interpolating across countries with different observed characteristics, the donor pool is limited to countries that closely resemble the PetroCaribe members. As a first filter, we selected countries that belong to the same income level as the PetroCaribe countries, according to the World

Table 4
Fit And Treatment Effects On GDP Per Capita

Country	*Pre-treatment fit*	*Average effect (%)*	*Gap 2014 (%)*	*Pseudo p-value*[b]
Antigua and Barbuda	0.186[a]	4.41	0.108	0.4(4/10)
Cuba	0.867	26.29	41.550	0.066 (1/15)
Dominica	0.938	11.910	14.190	0.0833 (1/12)
Grenada	0.862	−5.430	−5.300	0.2308 (3/13)
Guyana	0.565	11.190	12.910	0.125 (1/8)
Haiti	−4.741[a]	−10.450	−13.840	0.45 (5/11)
Jamaica	0.086[a]	−18.390	−27.410	0.0833 (1/12)
Nicaragua	0.880	−9.300	−12.350	0.125 (1/8)
Dominican Rep	0.829	7.390	14.580	0.2 (2/10)
St.Vincent and the Grenadines	0.864	−1.870	−9.200	0.5 (5/10)
St.Kitts and Nevis	0.919	−4.030	−0.050	0.5 (5/10)

[a]Countries not included in the main analysis due to poor fit.
[b]*p*-values calculated based on placebo tests.

Bank classification (World Bank, 2017). Later, we choose as donor pool those countries which values of the outcome variable lie within the range of the 50 percent of the value of the outcome of interest of the PetroCaribe country. This is a crucial step in the construction of the synthetic country, since if the control countries are not sufficiently similar, any difference in the outcome of the two sets may simply reflect disparities in their characteristics (Abadie *et al*., 2015). The donor pool as well as the descriptive statistics are shown in Appendix C.

5 Results

As mentioned in Section 2, the first step in the analysis involves the choice of the appropriate specification, i.e. the one that minimizes the RMSPE for each country and outcome of interest. For the sake of brevity, the results of each specification are shown in Appendix A. Control country and covariate weights are displayed in Appendix B. Robustness is discussed in the context of the main findings. The results of the placebo test are displayed in Appendix D, E and F.

5.1 Economic Growth

As mentioned in Section 4, Haiti and Jamaica are removed from main analysis because they did not satisfy the conditions to carry out an adequate analysis. On one hand, the extreme low values of Haiti compared to the donor pool, and the exogenous significant shock in Jamaica. For illustrative

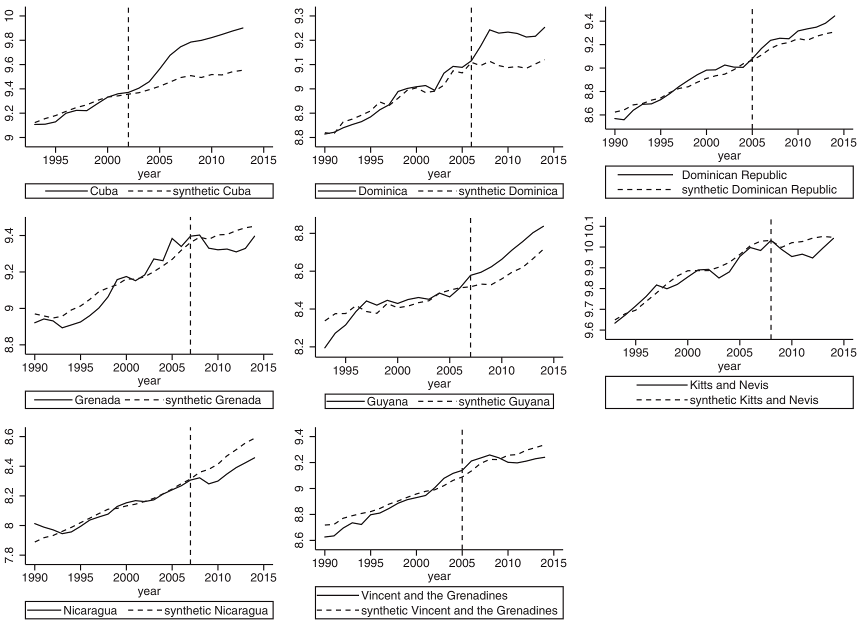

Fig. 1. Treated vs. Synthetic Control. GDP per capita

purposes, both circumstances are reflected in the low values of the pre-treatment fit shown in Table 4. For Antigua and Barbuda, the pre-treatment fit is weak, with a low value of 0.186. Moreover, the results are not robust to any falsification test performed (see appendixes D, E and F), thus, Antigua and Barbuda is also dropped from the main analysis.

Fig. 1 illustrates the synthetic control estimates for the PetroCaribe countries with a good pre-treatment fit, as mentioned in Table 4.

In four countries, PetroCaribe significantly boosted economic development. The largest effect can be seen in Cuba, with an average gain of 26.29 percent in GDP per capita and a gain of 41.55 percent in 2014. The results are highly robust to the placebo test, with a pseudo *p*-value of 0.066. In Dominica, the pre-treatment fit of 0.938 is nearly perfect. The average gain in its per capita GDP due to PetroCaribe is 11.19 per cent and in 2014 per capita GDP is 14.19 per cent higher than it would have been without the agreement. Guyana experienced an average gain in the post-treatment period of 11.19 per cent, while in the Dominican Republic, the gain was 7.39per cent. All the results are robust to the placebo test, which is reflected in the pseudo *p*-value, and to the leave-one-out test, i.e. the positive effect of PetroCaribe in is not driven by any control country in the donor pool.

In contrast, Grenada, Nicaragua, St. Vincent and the Grenadines and St. Kitts and Nevis, did not experience a higher per capita GDP than they would have had without PetroCaribe. Grenada, which received the first shipment of oil in 2007, experienced during the post-treatment period a per capita GDP that was 5.43per cent below its synthetic counterfactual. As can be seen in Fig. 1, Grenada experienced a decrease in its per capita GDP in 2008, while its synthetic counterfactual continued with the growing trend. The gap narrows towards the end of the post-treatment period, with a gap of −5.3 per cent in 2014. In Nicaragua, the SCM estimated an average decrease in the post-treatment period of −9.3 per cent in per capita GDP. As in Grenada, Nicaragua experienced a decrease in its per capita GDP in 2008 while the trend in its synthetic continued upwards. In both countries, results are robust to the placebo test.

St. Vincent and the Grenadines and St. Kitts and Nevis also show an average decrease in their per capita GDP, −1.87 per cent and −4.03 per cent percent, respectively. However, the results are not robust. The pseudo *p*-value in both countries indicate that the probability to obtain a placebo country with an effect higher or equal to that experienced in the treated country is fifty percent, concluding that the effect of PetroCaribe in both countries is not statistically significant.

5.2 Social Development

The impact of PetroCaribe on social development is estimated only in six countries due to data availability. As can be seen in Table 5, the SCM achieved a good pre-treatment fit in all countries. Fig. 2 illustrates the effect of PetroCaribe on the Human Development Index.

Only Cuba experienced a positive effect. Twelve years after the Agreement, the HDI is 0.16 percent points higher than its synthetic counterpart. In Guyana and Haiti, PetroCaribe is not reflected in an increase in their HDI. The results are fairly robust to the placebo tests. Jamaica did not experience a higher HDI in comparison with its counterfactual, however, the results are not statistically significant, therefore, we can not drive conclusions about the real effects of PetroCaribe in the country. Finally, in Nicaragua and the Dominican Republic, PetroCaribe had no discernible effect, the divergence from their respective counterfactuals is small.The results in both countries are statistically significant.

5.3 Carbon Dioxide Emissions Per Capita

The synthetic control method could estimate a good match in the pre-treatment period for all the countries except for Cuba. As can be seen in Table 6, the pre-treatment fit in Cuba is −0.379, thus, we exclude this country from the main analysis.

Fig. 3 plots the trajectories of the PetroCaribe countries and their estimated synthetic counterfactual. First, let us focus on the case of Antigua and Barbuda and Guyana, the only two countries that experienced higher

Table 5
Fit And Average Treatment Effect On HDI

Country	*Pre-treatment fit*	*Average effect (% points)*	*Effect in T (HDI points)*	*Pseudo p-value*[a]
Cuba	0.9194	2.100	0.0177	0.047 (1/21)
Dominican Republic	0.9982	−1.198	−0.0047	0.059 (1/17)
Guyana	0.9135	−3.011	−0.0297	0.071 (1/14)
Jamaica	0.8847	−3.460	−0.0216	0.1818 (2/11)
Nicaragua	0.9908	−1.780	−0.014	0.1 (1/10)
Haiti	0.5751	−4.051	−0.022	0.077 (1/13)

[a] *p*-values calculated based on placebo tests.

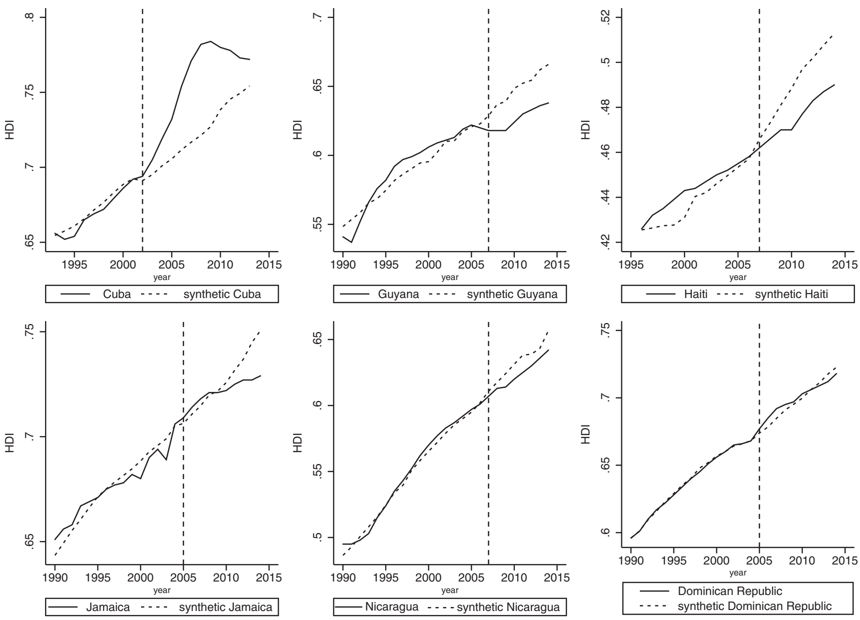

FIG. 2. Treated vs. Synthetic Control. Human Development Index (HDI)

TABLE 6
FIT AND TREATMENT EFFECTS ON CO_2 PER CAPITA EMISSIONS

Country	*Pre-treatment fit*	*Average effect (%)*	*Gap 2013(%)*	*Pseudo p-value*[b]
Antigua and Barbuda	0.6102	6.80	16.91	0.083 (1/12)
Cuba	−0.3799[a]	0.47	−2.04	0.928 (13/14)
Dominica	0.9251	−13.06	−17.72	0.2 (2/10)
Grenada	0.9390	5.03	19.26	0.461 (6/13)
Guyana	0.6191	7.88	14.31	0.5 (5/10)
Jamaica	0.8173	−27.60	−49.10	0.066 (1/15)
Nicaragua	0.9587	0.30	−11.32	0.333 (3/9)
The Dominican Rep.	0.8378	−5.79	−10.44	0.667 (6/9)
St. Vincent and the Grenadines	0.9074	7.56	−6.62	0.273 (3/11)
St. Kitts and Nevis	0.7959	1.47	−4.17	0.6 (6/10)

[a]Country not include in the main analysis due to poor fit.
[b]*p*-values calculated based on placebo tests.

levels of CO_2 per capita emissions at the end of the treatment period, compared to their synthetic estimates. Antigua and Barbuda exhibit an average increase of 6.80 per cent with a difference of 16.91 per cent at the end of the treatment period. The pseudo p-value of 0.083 gives us confidence in our results, as does the robustness seen in the leave-one-out test. Guyana has an average increase of 7.88 per cent and at the end of the treatment period, the CO_2 per capita emissions are 14.3 per cent higher than that of its synthetic counterfactual. However, the placebo test shows that 4 of the 10 control countries have a higher pre/post-RSME than that of Guyana. As such, we cannot conclude that PetroCaribe increased emissions in this country. In Grenada, the path of the treated is slightly higher than the synthetic counterfactual, 5.03 per cent on average. With a pseudo p-value of 0.461 and a highly robust leave-one-out test, the results for Grenada are statistically significant.

We next move to the countries where PetroCaribe had a negative or close to zero effect in their CO_2 per capita emissions, i.e. have a lower level of emissions compared to their counterfactual. Dominica has, on average, 13.06 per cent less emissions than what would have had without PetroCaribe. At the end of the post-treatment period, the emissions are 17.72 per cent lower than those of its synthetic. In Nicaragua, the estimated effect of the agreement at the end of the treatment is a difference of −11.32 per cent in comparison with its counterfactual. St. Vincent and the Grenadines has an estimated effect of 6.62 per cent fewer emissions than its counterfactual. The effects are statistically significant in all these countries.

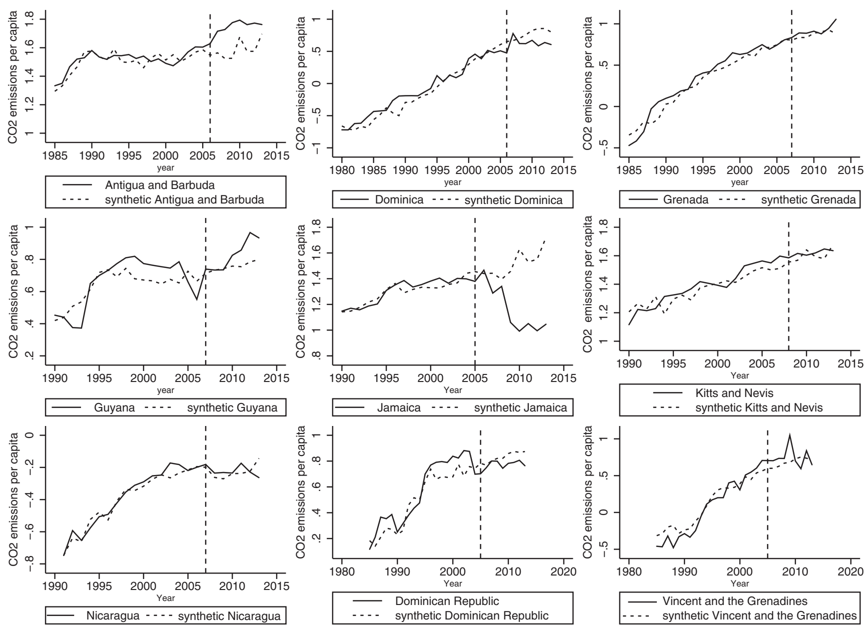

FIG. 3. Treated vs. Synthetic Control. CO_2 per capita emissions

Table 7
Fit And Treatment Effects On Electricity Use Per Capita

Country	*Pre-treatment fit*	*Average effect (%)*	*Gap 2013 (%)*	*Pseudo p-value*[b]
Antigua and Barbuda	0.549[a]	16.78	13.21	0.58 (7/12)
Cuba	0.858	−13.95	−15.73	0.125 (1/8)
Dominica	0.865	−5.70	−12.68	0.714 (5/7)
Grenada	0.862	−11.78	−20.97	0.111 (1/9)
Guyana	0.420[a]	13.12	20.25	0.833 (10/12)
Jamaica	0.700	−49.24	−69.58	0.071 (1/14)
Nicaragua	0.707	4.85	7.11	0.571 (4/7)
Dominican Rep	0.520[a]	−6.62	−16.90	0.727 (8/11)
St. Vincent and the Grenadines	0.969	0.62	−11.73	0.222 (2/9)
St. Kitts and Nevis	0.627	17.12	23.00	0.083 (1/12)

[a]Country not include in the main analysis due to poor fit.
[b]*p*-values calculated based on placebo tests.

Finally, the Dominican Republic experienced an average decline of 5.79 during the treatment period, while St. Kitts and Nevis has a small difference of −4.17 per cent compared to its synthetic counterfactual. The effects, however, are not statistically robust to the placebo test, nor to the leave-one-out test. Therefore, we cannot be confident about the true effect.

Summing up, there is little evidence that PetroCaribe led to an increase in per capita CO_2 emissions in the member countries.

5.4 Electricity Use Per Capita

In the study of the effect of PetroCaribe in per capita electricity, the SCM was not able to estimate a good pre-treatment match for Antigua and Barbuda, Guyana and the Dominican Republic. These three countries and Jamaica are removed from the main analysis. As can be seen in Table 7 and Fig. 4, in the rest of the countries, the pre-treatment fit is fairly good.

Although all countries show an upward trend in their electricity consumption, only two countries, Nicaragua and St. Kitts and Nevis, increased their electricity consumption after joining PetroCaribe. In Nicaragua, the increase was on average 4.85 per cent during the treatment period and in 2014, the last treatment year, the electricity use was 7.11 per cent higher than that of its synthetic estimate. The effects, however, are not statistically significant. In St. Kitts and Nevis, the electricity consumption was, on average, 17.12 per cent higher than that its counterfactual. The pseudo *p*-value is 0.083, highly statistically significant. In contrast, electricity use in Cuba and Grenada is less than the electricity use in heir synthetic estimates. For

Cuba, the SCM estimated an average difference of −13.95 per cent. For Grenada, the effect is −11.78 per cent. The pseudo *p*-value in both countries is statistically significant. Dominica also experienced a per capita electricity use lower that than its counterfactual. The effect, however, is not robust to the placebo test, neither for the leave-one-out. Finally, in St. Vincent and the Grenadines, PetroCaribe had an average effect close to zero, 0.62 per cent higher than the synthetic counterfactual.

6 Conclusion and Policy Implications

We use synthetic controls to investigate the effect of the PetroCaribe Energy Cooperation Agreement on economic growth, human development, carbon dioxide emissions and electricity use. The PetroCaribe Agreement caused an increase in economic growth in five of the nine countries analyzed: Cuba, Dominica, Guyana, the Dominican Republic and St. Kitts and Nevis. The impact on Nicaragua is negative but small. In Grenada and St. Vincent, the result is not robust to the placebo test. Cuba and the Dominican Republic have the largest oil quota among all the members.

However, the positive effects on economic growth are not reflected in social development, a key target of PetroCaribe. Only Cuba had a positive difference of 0.16 percent points against its counterfactual. None of the other countries achieved a higher Human Development Index compared

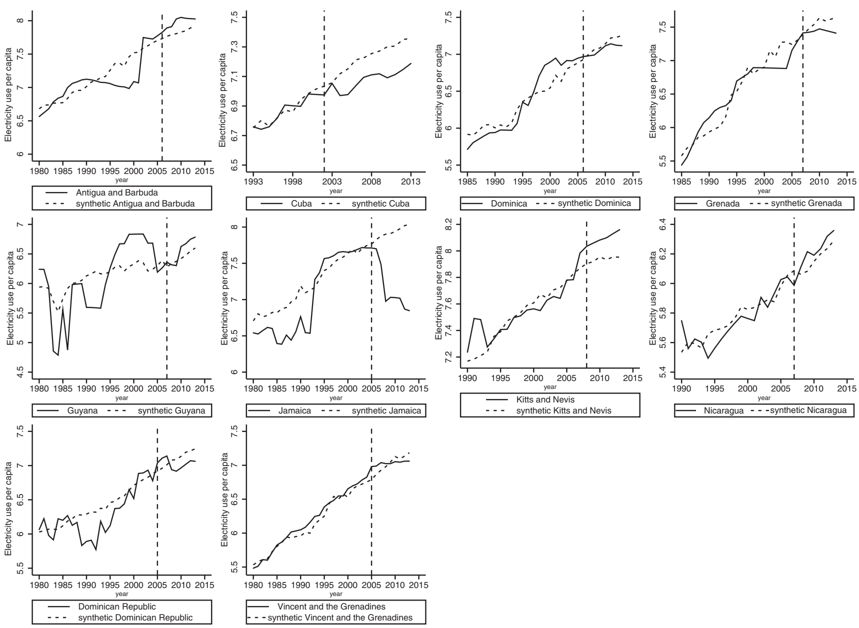

Fig. 4. Treated vs. Synthetic Control. Electricity use per capita

to their synthetic control. Although all show an overall increase in their HDI during the period under analysis, PetroCaribe did not have the positive impact that was expected by its sponsors. These results contradict the conclusion of SELA 2015, p. 20) that PetroCaribe "has made a bigger contribution" on the HDI in the beneficiary countries. Rather, they confirm one criticism of energy subsidies, that they do not always improve the social development of individuals. The Human Development Index is dominated by education and health, which are stock variables that change only slowly over time. PetroCaribe does not have an impact in the short run analyzed here, but it may have in the long run.

PetroCaribe had no effect on per capita CO_2 emissions. Emissions neither increased—as may have been expected from a programme that subsidizes oil—nor fell—the stated intention of the recipient countries. Although some countries show an increase in emissions, the difference with their counterfactual is minimal. We can conclude that PetroCaribe did not result in a worsening of CO_2 per capita emissions. As economic growth accelerated, this implies that PetroCaribe must have reduced the carbon intensity of the recipient economies.

Regarding electricity use, some results are positive and others negative, but only two are statistically significant and economically meaningful. Jamaica saw a large drop, and St. Kitts and Nevis a large increase. However, these outcomes are not strongly supported by the leave-one-out test. Nicaragua, St. Kitts and Nevis and St. Vincent and the Grenadines were beneficiaries of a series of power generation projects, supported by PetroCaribe. Access to cheaper oil for power generation and accelerated growth appears to have been offset by greater efficiency, perhaps in terms of reduced transmission and distribution losses, which are around 20 per cent, one of the highest in the world. We cannot draw firm conclusions about the effects of PetroCaribe on electricity use in its member countries.

The policy implication is that an energy subsidy like PetroCaribe can promote economic development in the beneficiary countries without a significant worsening of per capita CO_2 emissions. PetroCaribe can provide the insights and evidence that oil subsidies of this type, in which the savings derived from the oil bill are destined for a series of energy infrastructure along with social development programs are not incongruent with the discourse of sustainable development.

Further research should investigate how a subsidy of this kind impacts the development of renewable energy sources, and whether it acts as a disincentive to the transition towards alternative sources of energy. This is of particular interest for countries that heavily rely on imported fossil fuel for power generation. A deeper analysis into the impact of PetroCaribe on the structure of economic activity and public expenditure would be useful. The analysis here should be repeated when the data allow for an analysis of the impact in the long run. The limitations of the methodology used did not allow us to estimate the impact of PetroCaribe in Haiti, the poorest country among the beneficiaries and the most dependent on Venezuelan oil. We need better counterfactuals for this country. Lack of fit for some countries, should not be interpreted as a lack of effect. Another caveat is that the synthetic control method does not explicitly consider the interactions and spillovers between the treated countries, whose economies are integrated. Furthermore, PetroCaribe is a composite treatment, not just the programme itself but also through its geopolitical realignment. All this is deferred to future research.

Appendix A: Specification Results

Table A1
Specifications GDP Percapita

Country	*1*	*2*	*3*	*4*	*5*	*3*	*4*	*5*
Antigua and Barbuda	0.2094	0.1604	0.1304	0.1220*	0.1380	90,05	90,97,05	90,97,98,04,05
Cuba	0.1177	0.1141	0.1095	0.1092*	0.1116	93,01	93,00,01	93,96,97,00,01
Dominica	0.1583	0.1816	0.1819	0.0962*	0.0962	90,05	90,96,05	90,95,96,04,05
Grenada	0.1769	0.1996	0.1372	0.1372	0.1280*	90,06	90,96,06	90,95,96,05,06
Guyana	0.1309	0.1286	0.1298	0.1298	0.1286*	93,06	93,98,06	93,98,99,05,06
Haiti	0.1853	0.1159*	0.1521	0.17316	0.1297	96,06	96,01,06	96,01,02,05,06
Jamaica	0.1216	0.1041	0.1193	0.1086	0.1086*	90,04	90,96,04	90,96,97,03,04
Nicaragua	0.1818	0.1517	0.1517	0.1517	0.1517*	90,06	90,96,06	90,95,96,05,06
Dominican Republic	0.1481	0.1587	0.1076	0.1085	0.1023*	90,04	90,97,04	90,95,96,03,04
St.Vincent & Grenadines	0.1741	0.1517	0.0778*	0.0934	0.0802	90,04	90,96,04	90,95,96,03,04
St.Kitts& Nevis	0.1990	0.1363	0.2425	0.2425	0.1362*	93,07	93,00,07	93,99,00,06,07

*Selected specification.

Table A2
Specifications Human Development Index

Country	*1*	*2*	*3*	*4*	*5*	*3*	*4*	*5*
Cuba	0.0182	0.0148	0.0129	0.0124*	–	93,01	93,97, 01	–
Dominican Republic	0.0155	0.0107*	0.0126	0.0122	0.0124	90,04	90,98,04	90,95,96,03,04
Guyana	0.0279	0.0206*	0.0227	0.0223	0.0231	90,06	90,98,06	90,98,99,05,06
Jamaica	0.0177	0.0158*	0.0168	0.0166	0.0159	90,04	90,97,04	90,97,98,03,04
Nicaragua	0.0215	0.0132	0.0148	0.0149	0.0121*	90,06	90,96,06	90,95,96,05,06
Haiti	0.0274	0.0164	0.016*	0.0173	–	96,06	96,01,06	–

*Selected specification.

TABLE A3
SPECIFICATIONS CO_2 PER CAPITA

Country	*1*	*2*	*3*	*4*	*5*	*3*	*4*	*5*
Antigua and Barbuda	0.3441	0.3022	0.2959	0.2587	0.1921*	85,05	85,97,05	85,90,97,98,05
Cuba	0.3538	0.1756	0.1831	0.1905	0.1706*	93,01	93,96,01	93,96,00,01
Dominica	0.4209	0.3471	0.3239	0.3239	0.3187*	80,05	80,96,05	80,96,07,05
Grenada	0.3061	0.2878	0.2823	0.2892	0.1410*	85,06	85,96,06	85,95,96,05,06
Guyana	0.2304*	0.2341	0.2473	0.2456	0.2456	90,06	90,97,06	90,97,98,05,06
Jamaica	0.1942	0.2298	0.1887	0.1780	0.1616*	90,04	90,96,04	90,96,97,03,04
Nicaragua	0.3893	0.3724	0.2933	0.2933*	0.2933	91,06	91,97,06	91,96,97,05,06
Dominican Republic	0.2371	0.2461	0.2400	0.1771	0.1938*	85,04	85,96,04	85,96,97,03,04
St. Vincent & Grenadines	0.2148	0.1913	0.1934	0.1821	0.1586*	85,04	85,95,04	85,95,96,03,04
St. Kitts & Nevis	0.3444	0.3286	0.3760	0.2279	0.2040*	90,06	90,98,06	90,97,98,06,07

*Selected specification.

TABLE A4
SPECIFICATIONS ELECTRICITY USE

Country	*1*	*2*	*3*	*4*	*5*	*3*	*4*	*5*
Antigua and Barbuda	0.2789	0.2215	0.2181	0.2520	0.1325*	80,05	80,92,05	80,92,93,04,05
Cuba	0.1674	0.1301	0.1174	0.1174	0.1174*	93,01	93,97,01	93,96,97,01
Dominica	0.3894	0.3432	0.3398	0.2205	0.2205*	85,05	85,96,05	85,95,96,04,05
Grenada	0.6042	0.3411	0.2657*	0.3183	0.3056	80,06	80,96,06	80,96,97,05,06
Guyana	0.4054	0.3430	0.3163	0.3257	0.2482*	80,06	80,96,06	80,96,97,05,06
Jamaica	0.2244	0.1816	0.1843	0.1779	0.1265*	80,04	80,92,04	80,96,97,03,04
Nicaragua	0.331*	0.331	0.5766	0.5766	0.5766	80,06	80,96,06	80,96,97,05,06
Dominican Republic	0.2749	0.2265	0.2865	0.2102	0.2101*	80,04	80,96,04	80,96,97,03,04
St. Vincent & Grenadines	0.5852	0.5339	0.4812	0.4077	0.3052*	90,04	90,96,04	90,96,97,03,04
St. Kitts & Nevis	0.1842	0.14	0.1431	0.1868	0.149*	80,07	80,94,07	80,93,94,06,07

*Selected specification

Appendix B: Weights

GDP Per Capita

Table B1
Antigua and Barbuda

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	ln GDP(1990)	9.750	9.763	0.000
Bahamas	0.502	ln GDP(1997)	9.808	9.804	0.453
Barbados	0.283	ln GDP(2005)	9.972	9.964	0.320
Chile	0	Trade openness	149.644	102.109	0.062
Costa Rica	0	Industry share	17.705	22.461	0.038
Trinidad & T	0.105	Services share	79.049	70.016	0.000
Uruguay	0	Agriculture share	3.246	3.633	0.000
Malaysia	0.11	G. primary	111.139	98.833	0.005
Turkey	0	G. secondary	98.923	88.747	0.033
		Internet (1996)	2.858	1.122	0.016
		Internet (2004)	24.267	32.623	0.010
		Urban pop	32.851	57.715	0.054
		Inflation (99–05)	1.689	2.218	0.010
RMSPE	0.05526556				

Table B2
Cuba

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	ln GDP(1993)	9.107	9.123	0.288
Bahamas	0.319	ln GDP(2000)	9.332	9.333	0.433
Barbados	0.066	ln GDP(2001)	9.360	9.343	0.252
Chile	0	Trade openness	30.688	76.243	0.001
Colombia	0	Industry share	23.802	25.587	0.009
Costa Rica	0	Services share	67.148	65.241	0.007
Ecuador	0	Agriculture share	9.050	8.258	0.006
Panama	0	G. primary	102.065	109.399	0.000
Peru	0.237	G. secondary	81.350	76.558	0.003
Uruguay	0	Internet (1996)	0.032	0.652	0.000
Malaysia	0	Urban pop	74.694	68.698	0.002
Thailand	0				
Tunisia	0.378				
Fiji	0				
RMSPE	0.031914				

TABLE B3
DOMINICA

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.069	ln GDP(1990)	8.814	8.820	0.134
Colombia	0	ln GDP(1996)	8.914	8.946	0.289
Ecuador	0	ln GDP(2005)	9.089	9.066	0.347
Guatemala	0	Trade openness	106.950	118.836	0.024
Paraguay	0	Industry share	19.156	21.157	0.031
Peru	0	Services share	62.930	66.613	0.000
Lucia	0.571	Agriculture share	17.914	12.230	0.030
Indonesia	0	G. primary	113.306	114.794	0.020
Philippines	0	G. secondary	103.145	74.107	0.036
Tunisia	0	Internet (1996)	1.166	0.420	0.027
Fiji	0.36	Internet (2004)	30.320	15.192	0.032
		Urban pop	65.112	36.653	0.002
		Inflation (97–05)	1.386	2.716	0.028
RMSPE	0.0229004				

TABLE B4
DOMINICAN REPUBLIC

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Colombia	0	ln GDP (1990)	8.569	8.624	0.000
Costa Rica	0	ln GDP (1995)	8.730	8.745	0.455
Ecuador	0	ln GDP (1996)	8.782	8.792	0.000
Paraguay	0	ln GDP (2003)	9.008	8.986	0.345
Peru	0.147	ln GDP (2004)	9.006	9.036	0.000
Uruguay	0	Trade openness	78.918	78.488	0.018
Indonesia	0.018	Industry share	33.438	31.836	0.015
Thailand	0.071	Services share	57.073	55.389	0.000
Tunisia	0.763	Agriculture share	9.488	12.706	0.026
		G. primary	105.194	113.649	0.007
		G. secondary	55.863	63.736	0.000
		Internet (1996)	0.075	0.066	0.026
		Internet (2004)	8.866	9.385	0.017
		Urban pop	59.591	60.774	0.084
		Inflation (97–04)	15.042	3.291	0.007
RMSPE	0.048652				

Table B5
Grenada

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Barbados	0.396	ln GDP(1990)	8.921	8.970	0.133
Colombia	0	ln GDP(1995)	8.926	9.013	0.000
Costa Rica	0	ln GDP(1996)	8.960	9.049	0.261
Ecuador	0	ln GDP(2005)	9.384	9.269	0.000
Paraguay	0	ln GDP(2006)	9.340	9.319	0.349
Peru	0.243	Trade openness	100.548	74.035	0.005
Uruguay	0	Industry share	20.566	25.123	0.052
Angola	0	Services share	71.115	61.646	0.095
Indonesia	0	Agriculture share	8.319	7.851	0.019
Philippines	0	G. primary	110.761	109.939	0.023
Thailand	0	G. secondary	102.117	83.546	0.006
Tunisia	0.362	Internet (1996)	0.298	0.224	0.013
		Internet (2004)	19.571	26.235	0.021
		Urban pop	35.069	53.283	0.007
		Inflation (97–06)	2.033	3.100	0.018
RMSPE	0.05783058				

Table B6
Guyana

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Guatemala	0	ln GDP (1993)	8.195	8.337	0.000
Paraguay	0	ln GDP (1998)	8.421	8.377	0.000
Papua N.G.	0.242	ln GDP (1999)	8.446	8.429	0.000
Philippines	0	ln GDP (2005)	8.464	8.500	0.641
Vietnam	0.097	ln GDP (2006)	8.513	8.513	0.000
Fiji	0.661	Trade openness	203.609	117.107	0.120
Ghana	0	Industry share	29.455	27.424	0.007
		Services share	36.874	50.311	0.000
		Agriculture share	33.672	22.265	0.025
		G. primary	101.131	96.886	0.046
		G. secondary	94.122	63.956	0.074
		Internet (1997)	0.132	0.172	0.010
		Urban pop	28.750	37.051	0.077
		Inflation (97–06)	5.395	4.518	0.000
RMSPE	0.056329				

Table B7
Jamaica

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	ln GDP(1990)	8.910	8.896	0.136
Colombia	0.618	ln GDP(1996)	9.050	9.029	0.460
Ecuador	0	ln GDP(1997)	9.030	9.038	0.000
Guatemala	0.102	ln GDP(2003)	9.050	9.065	0.000
Paraguay	0	ln GDP(2004)	9.058	9.108	0.243
Peru	0	Industry share	29.547	27.779	0.006
Lucia	0.242	Services share	62.983	61.117	0.045
Philippines	0	Agriculture share	7.469	11.104	0.025
Thailand	0.038	G. primary	98.113	112.453	0.009
Tunisia	0	G. secondary	82.149	61.766	0.003
Fiji	0	Internet (1996)	0.591	0.373	0.013
		Internet (2004)	10.000	11.739	0.058
		Urban pop	51.077	56.336	0.002
		Inflation (97–04)	8.804	7.894	0.002
RMSPE	0.04037694				

Table B8
Nicaragua

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.455	ln GDP(1990)	8.013	7.889	0.000
Guatemala	0.083	ln GDP(1995)	7.994	8.019	0.000
Angola	0	ln GDP(1996)	8.037	8.049	0.000
Nigeria	0	ln GDP(2005)	8.241	8.246	0.516
Philippines	0	ln GDP(2006)	8.268	8.282	0.000
Vietnam	0.184	Trade openness	61.690	67.069	0.026
Ghana	0.277	Industry share	23.173	30.344	0.000
		Services share	56.674	45.944	0.041
		Agriculture share	20.153	23.612	0.032
		G. primary	104.257	101.295	0.200
		G. secondary	52.154	59.726	0.128
		Internet (1996)	0.206	0.220	0.020
		Internet (2004)	2.321	4.325	0.037
		Urban pop	54.256	47.366	0.000
		Inflation (99–06)	7.917	8.059	0.000
RMSPE	0.039379				

Table B9
St. Kitts And Nevis

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	ln GDP(1993)	9.633	9.649	0.256
Bahamas	0.468	ln GDP(1999)	9.820	9.861	0.000
Barbados	0.064	ln GDP(2000)	9.856	9.886	0.000
Chile	0	ln GDP(2006)	9.998	10.006	0.587
Costa Rica	0	ln GDP(2007)	9.983	10.029	0.000
St. Lucia	0	Trade openness	92.215	82.941	0.030
Trinidad & T	0.221	Industry share	26.839	26.267	0.029
Uruguay	0.24	Services share	70.628	68.925	0.000
Malaysia	0.008	Agriculture share	2.532	3.982	0.000
		G. primary	101.598	102.870	0.002
		G. secondary	92.583	89.766	0.031
		Internet (1996)	1.946	1.380	0.019
		Internet (2004)	24.738	23.889	0.028
		Urban pop	32.855	65.152	0.007
		Inflation (97–07)	3.920	4.515	0.010
RMSPE	0.02674026				

Table B10
St.Vincent And The Grenadines

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	ln GDP(1990)	8.626	8.718	0.234
Colombia	0	ln GDP(2004)	9.117	9.063	0.492
Costa Rica	0.419	Trade openness	99.629	83.557	0.037
Ecuador	0	Industry share	20.182	30.828	0.025
Paraguay	0	Services share	70.207	55.592	0.000
Peru	0	Agriculture share	9.611	13.638	0.000
Indonesia	0.033	G. primary	117.224	111.123	0.009
Philippines	0.132	G. secondary	82.566	61.796	0.014
Tunisia	0.416	Internet (1996)	0.483	0.373	0.081
		Internet (2004)	7.371	13.038	0.035
		Urban pop	44.093	57.124	0.055
		Inflation (97–04)	1.211	7.009	0.018
RMSPE	0.054266				

Table B11
Haiti

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.177	ln GDP(2005)	7.354	7.354	0.705
Nigeria	0	ln GDP(2006)	7.360	7.370	0.274
Papua N.G	0	Trade openness	48.791	55.510	0.004
Vietnam	0	G. primary	106.444	83.875	0.001
Ghana	0	Internet	2.179	0.796	0.000
Mauritania	0	Urban pop	38.275	33.420	0.015
Nepal	0	Inflation (99–07)	17.162	9.746	0.001
Mali	0.372				
Benin	0.408				
Madagascar	0.043				
RMSPE	0.10551935				

Human Development Index HDI

Table B12
Cuba

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0.557	HDI(1993)	0.656	0.655	0.270
Barbados	0	HDI(1997)	0.669	0.672	0.360
Bolivia	0	HDI(2001)	0.692	0.692	0.368
Chile	0	ln GDP	9.218	9.068	0.002
Colombia	0	Access electricity	97.000	83.278	0.000
Costa Rica	0	Internet(%)	0.323	1.510	0.000
Ecuador	0.214	Urban pop (%)	74.694	72.021	0.000
Panama	0				
Paraguay	0				
Peru	0				
Uruguay	0				
Indonesia	0				
Malaysia	0				
Papua N.G.	0				
Philippines	0				
Thailand	0				
Tunisia	0				
Turkey	0.025				
Vietnam	0				
Fiji	0				
Ghana	0.205				
RMSPE	0.003359				

Table B13
Dominican Republic

Country weights		Covariates	Treated	Synthetic	Weights V
Barbados	0.023	HDI(2003)	0.666	0.666	0.661
Bolivia	0.299	HDI(2004)	0.668	0.668	0.337
Colombia	0.367	ln GDP	8.824	8.835	0.001
Costa Rica	0.241	Access electricity	84.100	82.843	0.000
Ecuador	0	Internet(%)	3.027	3.295	0.001
Guatemala	0	Urban pop(%)	59.591	61.707	0.000
Panama	0				
Paraguay	0				
Peru	0				
Uruguay	0				
Malaysia	0				
Philippines	0				
Thailand	0				
Tunisia	0				
Turkey	0				
Fiji	0.07				
RMSPE	0.00099634				

Table B14
Guyana

Country weights		Covariates	Treated	Synthetic	Weights V
Bolivia	0.23	HDI(2007)	0.622	0.621	0.653
Colombia	0	HDI(2006)	0.620	0.622	0.345
Guatemala	0	ln GDP	8.346	8.500	0.001
Panama	0.132	Access electricity	73.250	69.140	0.001
Paraguay	0.459	Internet(%)	3.464	2.395	0.000
Peru	0	Urban pop (%)	28.881	49.017	0.000
Indonesia	0				
Papua N.G.	0.179				
Philippines	0				
Tunisia	0				
Turkey	0				
Vietnam	0				
Fiji	0				
RMSPE	0.007836				

Table B15
Jamaica

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	HDI(2004)	0.706	0.705	0.930
Colombia	0	ln GDP	9.012	8.954	0.013
Costa Rica	0.376	Access electricity	85.500	76.886	0.001
Ecuador	0.209	Internet(%)	3.062	3.441	0.023
Guatemala	0	Urban pop (%)	51.077	52.168	0.033
Paraguay	0				
Peru	0				
Indonesia	0				
Thailand	0.037				
Fiji	0.378				
RMSPE	0.00492658				

Table B16
Nicaragua

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.065	HDI(1990)	0.495	0.486	0.007
Colombia	0	HDI(1995)	0.524	0.525	0.287
Guatemala	0.509	HDI(1996)	0.535	0.534	0.209
Paraguay	0	HDI(2005)	0.597	0.595	0.281
Peru	0	HDI(2006)	0.601	0.602	0.214
Indonesia	0.111	ln GDP	8.091	8.356	0.001
Philippines	0	Access electricity	71.500	78.863	0.000
Tunisia	0	Internet(%)	1.061	2.602	0.001
Vietnam	0.314	Urban pop (%)	54.256	38.297	0.000
RMSPE	0.003314				

Table B17
Haiti

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Benin	0	HDI(1996)	0.426	0.426	0.551
Cameroon	0.414	HDI(2006)	0.458	0.457	0.428
Lesotho	0.112	ln GDP	7.420	7.651	0.015
Mali	0	Access electricity	32.882	24.376	0.005
Mauritania	0	Internet(%)	2.179	0.811	0.001
Niger	0	Urban pop (%)	38.275	27.686	0.001
Papua N.G.	0.475				
Senegal	0				
Sudan	0				
Tanzania	0				
Uganda	0				
Zimbabwe	0				
RMSPE	0.00657025				

CO_2 Per Capita Emissions

Table B18
Antigua and Barbuda

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	CO_2(1985)	1.333	1.294	0.098
Bahamas	0.384	CO_2 (1990)	1.580	1.576	0.128
Barbados	0.187	CO_2(1997)	1.541	1.460	0.173
Chile	0	CO_2(1998)	1.503	1.528	0.422
St. Lucia	0.151	CO_2(2005)	1.604	1.587	0.051
Uruguay	0	GDP per capita	9.305	9.595	0.017
Algeria	0	Trade openness	155.993	128.522	0.004
Malaysia	0	Population growth	1.022	1.196	0.023
Thailand	0	Urban pop	33.407	66.812	0.004
Malta	0.278	Industry share	17.705	21.759	0.015
Mauritius	0	Services share	79.049	72.085	0.038
		Agriculture share	3.246	3.585	0.026
RMSPE	0.041505				

Table B19
Cuba

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bahamas	0.353	CO_2 (1993)	1.001	0.931	0.087
Barbados	0.03	CO_2(1996)	0.902	0.912	0.166
Bolivia	0.064	CO_2(2000)	0.853	0.871	0.283
Chile	0	CO_2(2001)	0.825	0.824	0.195
Colombia	0.124	GDP per capita	8.042	8.979	0.006
Costa Rica	0	Trade openness	30.688	60.418	0.004
Ecuador	0.136	Population growth	0.423	1.444	0.002
Panama	0	Urban pop	74.694	74.396	0.008
Peru	0.14	Industry share	23.802	24.366	0.060
St. Lucia	0	Services share	67.148	66.296	0.122
Uruguay	0.153	Agriculture share	9.050	8.922	0.067
Indonesia	0				
Tunisia	0				
RMSPE	0.109312				

Table B20
Dominica

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	CO_2(1980)	-0.720	-0.660	0.052
Colombia	0	CO_2(1996)	0.030	0.039	0.415
Costa Rica	0	CO_2(1997)	0.131	0.131	0.447
Peru	0.024	CO_2(2005)	0.509	0.606	0.008
St. Lucia	0.146	GDP per capita	8.393	7.537	0.002
Nigeria	0	Trade openness	108.773	104.428	0.049
Vietnam	0.402	Urban pop	60.793	32.847	0.005
Fiji	0.021	Industry share	19.156	29.422	0.001
Mauritius	0.407	Services share	62.930	54.436	0.016
		Agriculture share	17.914	16.142	0.005
RMSPE	0.106419				

Table B21
Dominican Republic

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Colombia	0	CO_2(1985)	0.117	0.184	0.112
Costa Rica	0	CO_2(1995)	0.700	0.641	0.047
Ecuador	0.198	CO_2(1996)	0.769	0.738	0.000
Panama	0.143	CO_2(2003)	0.875	0.757	0.467
Peru	0	CO_2(2004)	0.699	0.745	0.219
Lucia	0.654	GDP per capita	8.053	8.499	0.003
Uruguay	0	Trade openness	76.130	115.872	0.000
Indonesia	0.005	Population growth	1.816	1.626	0.026
		Urban pop	58.296	38.126	0.023
		Industry share	33.438	21.022	0.036
		Services share	57.073	68.696	0.000
		Agriculture share	9.488	10.321	0.067
RMSPE	0.100072				

Table B22
Grenada

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.113	CO_2(1985)	-0.472	-0.345	0.145
Colombia	0	CO_2(1995)	0.405	0.353	0.078
Costa Rica	0	CO_2(1996)	0.424	0.416	0.209
Ecuador	0	CO_2(2005)	0.743	0.746	0.233
Panama	0	CO_2(2006) 0.805	0.811	0.305	
Peru	0	GDP per capita	8.586	8.086	0.002
St. Lucia	0.293	Trade openness	103.502	113.318	0.003
Uruguay	0	Population growth	0.220	1.248	0.001
Algeria	0	Urban pop	34.663	37.549	0.011
Tunisia	0	Industry share	20.566	27.526	0.002
Vietnam	0.131	Services share	71.115	60.914	0.002
Mauritius	0.463	Agriculture share	8.319	11.560	0.010
RMSPE	0.093669				

Table B23
Guyana

Country weights		Covariates	Treated	Synthetic	Weights V
Bolivia	0	CO_2	0.657	0.635	0.700
Colombia	0	GDP per capita	7.689	8.179	0.016
Costa Rica	0	Trade openness	206.318	87.880	0.101
Ecuador	0	Population growth	28.881	45.019	0.034
Peru	0	Urban pop	0.141	1.667	0.021
St. Lucia	0.35	Industry share	29.310	35.880	0.021
Algeria	0.407	Services share	36.065	52.959	0.073
Philippines	0.237	Agriculture share	34.624	11.161	0.033
Tunisia	0.006				
RMSPE	0.093529				

Table B24
Jamaica

Country weights		Covariates	Treated	Synthetic	Weights V
Argentina	0	CO_2(1990)	1.148	1.142	0.223
Bahamas	0.375	CO_2(1996)	1.352	1.363	0.136
Barbados	0.045	CO_2(1997)	1.386	1.290	0.070
Chile	0.01	CO_2(2003)	1.402	1.367	0.189
Colombia	0	CO_2(2004)	1.399	1.441	0.111
Ecuador	0	GDP per capita	8.477	8.911	0.003
Panama	0	Trade openness	99.956	92.983	0.011
St. Lucia	0	Population growth	0.778	1.302	0.003
Uruguay	0	Urban pop	51.077	52.317	0.023
Algeria	0.061	Industry share	29.547	29.336	0.085
Indonesia	0	Services share	62.983	63.183	0.138
Thailand	0.509	Agriculture share	7.469	6.870	0.010
Jordan	0				
Mauritius	0				
RMSPE	0.041067				

Table B25
Nicaragua

Country weights		Covariates	Treated	Synthetic	Weights V
Guatemala	0.593	CO_2(1991)	-0.748	-0.747	0.120
Paraguay	0.11	CO_2(1997)	-0.421	-0.408	0.154
Angola	0	CO_2(2006)	-0.199	-0.195	0.325
Nigeria	0	GDP per capita	7.125	7.557	0.012
Papua N.G.	0	Trade openness	61.090	68.072	0.053
Philippines	0.081	Population growth	1.727	2.315	0.033
Vietnam	0.086	Urban pop	54.376	43.836	0.050
Ghana	0.13	Industry share	23.173	30.318	0.000
		Services share	56.674	50.553	0.070
		Agriculture share	20.153	19.129	0.184
RMSPE	0.036404				

Table B26
St. Kitts And Nevis

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	CO_2(1990)	1.116	1.207	0.318
Bahamas	0.212	CO_2(1997)	1.368	1.289	0.252
Barbados	0.367	CO_2(1998)	1.418	1.374	0.000
Chile	0	CO_2(2006)	1.550	1.501	0.162
St. Lucia	0.114	CO_2(2007)	1.598	1.511	0.000
Malaysia	0.138	GDP per capita	9.344	9.217	0.036
Thailand	0.168	Trade openness	94.382	109.682	0.033
Tunisia	0	Population growth	1.181	1.117	0.045
Mauritius	0	Urban pop	33.122	46.231	0.035
		Industry share	26.797	23.490	0.028
		Services share	70.365	65.791	0.076
		Agriculture share	2.838	5.526	0.014
RMSPE	0.059623				

Table B27
St. Vincent And The Grenadines

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	CO_2(1985)	-0.459	-0.315	0.249
Colombia	0	CO_2(1995)	0.171	0.224	0.103
Costa Rica	0	CO_2(1996)	0.200	0.305	0.250
Panama	0	CO_2(2003)	0.603	0.538	0.186
Peru	0	CO_2(2004)	0.706	0.564	0.093
Lucia	0.682	GDP per capita	8.297	7.887	0.022
Uruguay	0	Trade openness	105.454	117.271	0.000
Indonesia	0	Population growth	0.228	1.474	0.003
Tunisia	0	Urban pop	43.000	26.245	0.013
Vietnam	0.318	Industry share	20.182	22.440	0.011
		Services share	70.207	63.055	0.051
		Agriculture share	9.611	14.505	0.019
RMSPE	0.118302				

Electricity Use Per Capita

Table B28
Antigua and Barbuda

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	Elec use(1980)	6.564	6.680	0.003
Barbados	0.281	Elec use(1992)	7.098	7.103	0.433
Chile	0.251	Elec use(1993)	7.076	7.147	0.214
Colombia	0	Elec use(2004)	7.726	7.669	0.109
Costa Rica	0	Elec use(2005)	7.773	7.706	0.194
Panama	0.306	GDP per capita	9.182	8.817	0.003
Uruguay	0	Pop density	170.796	249.666	0.013
Malaysia	0	Inflation(99-05)	1.689	2.350	0.001
Thailand	0.06	Urban pop	33.671	54.391	0.005
Turkey	0	Industry share	17.705	25.521	0.014
Mauritius	0.103	Services share	79.049	64.713	0.005
		Access Elec	86.550	91.279	0.006
RMSPE	0.211588				

Table B29
Cuba

Country weights		Covariates	Treated	Synthetic	Weights V
Colombia	0	Elec use(1993)	6.759	6.753	0.368
Costa Rica	0.487	Elec use(1996)	6.816	6.818	0.184
Ecuador	0.186	Elec use(1997)	6.906	6.873	0.000
Panama	0	Elec use(2001)	6.978	7.016	0.279
Paraguay	0	GDP per capita	8.042	8.339	0.008
Peru	0	Pop density	102.459	63.171	0.095
Tunisia	0.327	Urban pop	74.694	58.749	0.005
		Industry share	23.802	29.320	0.024
		Services share	67.148	56.539	0.000
		Access Elec	95.577	94.984	0.036
RMSPE	0.03333				

Table B30
Dominica

Country weights		Covariates	Treated	Synthetic	Weights V
Colombia	0	Elec use(1985)	5.714	5.917	0.000
Ecuador	0	Elec use(1995)	6.352	6.358	0.000
Paraguay	0	Elec use(1996)	6.308	6.410	0.606
Peru	0.496	Elec use(2004)	6.912	6.841	0.000
Lucia	0.321	Elec use(2005)	6.947	6.884	0.110
Vietnam	0.183	GDP per capita	8.489	7.937	0.000
		Urban pop	63.442	48.260	0.051
		Pop density	94.671	127.326	0.000
		Industry share	19.156	27.620	0.053
		Services share	62.930	60.537	0.165
		Access Elec	76.944	77.971	0.013
		Inflation(97-05)	1.386	3.307	0.002
RMSPE	0.166291				

Table B31
Dominican Republic

Country weights		Covariates	Treated	Synthetic	Weights V
Bolivia	0	Elec use(1980)	6.065	6.030	0.047
Colombia	0	Elec use(1996)	6.372	6.477	0.129
Ecuador	0.102	Elec use(1997)	6.377	6.530	0.000
Panama	0	Elec use(2003)	6.933	6.829	0.267
Paraguay	0.035	Elec use(2004)	6.779	6.882	0.130
Peru	0.371	GDP per capita	8.013	8.069	0.035
Philippines	0.061	Pop density	154.453	200.285	0.035
Tunisia	0.116	Urban pop	57.183	56.347	0.062
Fiji	0	Industry share	33.438	31.561	0.065
Mauritius	0.315	Services share	57.073	57.193	0.138
		Access Elec	85.507	84.325	0.074
		Inflation(97-04)	15.042	7.696	0.019
RMSPE	0.232526				

Table B32
Grenada

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Colombia	0	Elec use(1985)	5.439	5.578	0.278
Ecuador	0	Elec use(1994)	6.403	6.486	0.364
Paraguay	0	Elec use(1995)	6.694	6.539	0.000
Peru	0	Elec use(2005)	7.151	7.242	0.000
Lucia	0.403	Elec use(2006)	7.289	7.306	0.047
Thailand	0	GDP per capita	8.586	8.069	0.000
Mauritius	0.319	Urban pop	34.663	30.773	0.064
Bhutan	0.278	Pop density	294.617	278.542	0.018
		Industry share	20.566	26.722	0.026
		Services share	71.115	59.182	0.044
		Access Elec	80.865	74.196	0.142
		Inflation(97-06)	2.033	3.627	0.017
RMSPE	0.188041				

Table B33
Guyana

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0	Elec use(1980)	6.240	5.938	0.253
Ecuador	0	Elec use(1996)	6.487	6.276	0.026
Guatemala	0	Elec use(1997)	6.671	6.299	0.166
Paraguay	0.052	Elec use(2005)	6.192	6.302	0.095
Peru	0	Elec use(2006)	6.262	6.392	0.097
Indonesia	0	GDP per capita	7.593	7.357	0.040
Papua N.G.	0	Urban pop	29.325	49.498	0.013
Philippines	0	Pop density	3.856	59.912	0.012
Tunisia	0.495	Industry share	29.310	28.718	0.057
Vietnam	0	Services share	36.065	45.216	0.049
Ghana	0.453	Access Elec	74.304	69.112	0.190
		Inflation(97–06)	5.395	10.687	0.001
RMSPE	0.46148				

Table B34
Jamaica

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Argentina	0	Elec use(1980)	6.542	6.707	0.020
Chile	0.489	Elec use(1996)	7.576	7.433	0.117
Colombia	0	Elec use(1997)	7.606	7.508	0.289
Costa Rica	0	Elec use(2003)	7.718	7.707	0.184
Panama	0	Elec use(2004)	7.712	7.745	0.306
Paraguay	0	GDP per capita	8.379	8.823	0.005
Peru	0	Pop density	228.246	44.578	0.008
St. Lucia	0.124	Urban pop	49.936	79.108	0.004
Uruguay	0.386	Industry share	29.547	30.968	0.023
Thailand	0	Services share	62.983	61.101	0.032
Tunisia	0	Access Elec	82.067	95.320	0.003
Jordan	0	Inflation(97-04)	8.804	6.253	0.009
Mauritius	0				
RMSPE	0.299902				

Table B35
Nicaragua

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Bolivia	0.594	Elec use	5.745	5.763	0.849
Guatemala	0.213	GDP per capita	7.120	7.382	0.008
Indonesia	0	Urban pop	54.256	53.176	0.043
Nigeria	0.063	Pop density	40.209	45.270	0.013
Philippines	0	Industry share	23.173	30.801	0.015
Ghana	0.131	Services share	56.674	49.624	0.000
		Access Elec	71.465	62.131	0.035
		Inflation(97-06)	8.560	7.123	0.037
RMSPE	0.084705				

Table B36
St. Kitts And Nevis

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Barbados	0.397	Elec use(1990)	7.237	7.168	0.045
Chile	0.047	Elec use(1997)	7.497	7.501	0.364
Costa Rica	0	Elec use(1998)	7.510	7.533	0.038
Ecuador	0	Elec use(2006)	7.783	7.826	0.353
Panama	0	Elec use(2007)	7.984	7.870	0.156
Paraguay	0	GDP per capita	9.344	9.134	0.009
Peru	0	Urban pop	33.122	54.033	0.009
Lucia	0.142	Pop density	172.556	300.478	0.016
Uruguay	0.331	Industry share	26.797	22.732	0.002
Thailand	0.083	Services share	70.365	65.710	0.004
Mauritius	0	Access Elec	92.039	95.612	0.001
		Inflation(97-07)	3.920	5.210	0.003
RMSPE	0.148472				

Table B37
St.Vincent and the Grenadines

Country weights		*Covariates*	*Treated*	*Synthetic*	*Weights V*
Colombia	0	Elec use(1980)	5.483	5.531	0.406
Ecuador	0.117	Elec use(1996)	6.443	6.426	0.404
Paraguay	0.125	Elec use(1997)	6.484	6.541	0.090
Peru	0	Elec use(2003)	6.785	6.723	0.000
Philippines	0	Elec use(2004)	6.826	6.755	0.032
Tunisia	0.274	GDP per capita	8.201	7.719	0.000
Fiji	0.3	Urban pop	41.791	45.199	0.026
Bhutan	0.184	Pop density	272.871	35.516	0.002
		Industry share	20.182	29.692	0.007
		Services share	70.207	51.248	0.000
		Access Elec	75.805	71.354	0.030
		Inflation(97-04)	1.211	7.245	0.002
RMSPE	0.072729				

Appendix C: Descriptive Statistics

Table C1
Descriptive Statistics GDP

Country	*Average*	*Std*	*Min*	*Max*	*N*
Antigua and Barbuda	19865.90	2495.38	17153.70	26007.80	25
Cuba	13501.84	3699.51	9021.20	19950.30	24
Dominica	8556.77	1287.31	6729.34	10435.70	25
Dominican Republic	8445.86	2246.63	5213.79	12639.00	25
Grenada	9775.37	1756.52	7284.01	12117.20	25
Guyana	4820.43	1030.52	2928.07	6886.96	25
Haiti	1636.90	74.74	1502.03	1754.10	19
Jamaica	8319.73	348.05	7403.57	8908.90	25
St. Kitts and Nevis	19080.26	2758.21	13958.60	22968.00	25
Nicaragua	3592.78	561.75	2821.91	4707.45	25
St. Vincent and the Grenadines	8254.38	1731.22	5575.94	10494.00	25
Donor pool					
Algeria	11192.38	1534.00	9128.17	13553.90	25
Angola	4719.74	1380.21	3024.92	6955.96	25
Argentina	15642.04	2528.99	10833.50	19742.40	25
Bahamas	23754.97	1574.61	21216.90	26248.90	25
Barbados	14221.61	1311.81	11968.20	16083.20	25
Benin	1653.39	141.39	1452.92	1942.26	25
Bolivia	4688.03	725.17	3707.30	6325.07	25
Chile	15868.11	3654.76	9244.16	21923.40	25
Colombia	9338.00	1553.49	7533.52	12715.10	25
Costa Rica	10717.84	2055.39	7787.08	14266.40	25
Ecuador	8457.53	1087.54	7387.62	10923.00	25
Fiji	6901.12	699.00	5678.91	8348.21	25
Ghana	2564.76	599.47	1919.60	3894.00	25
Guatemala	6125.02	574.44	5159.40	7106.39	25
Indonesia	6797.71	1543.24	4477.31	10031.30	25
St. Lucia	9696.22	915.39	7938.43	11059.00	25
Madagascar	1422.92	76.04	1259.48	1660.73	25
Malaysia	17264.99	3922.58	10451.50	24459.70	25
Mali	896.56	116.59	716.41	1114.77	25
Mauritania	3026.30	343.34	2653.39	3693.54	25
Nepal	1637.56	314.08	1198.44	2278.13	25
Nigeria	3746.85	1065.01	2739.59	5639.45	25
Panama	12196.72	3565.81	7815.68	20059.10	25
Papua New Guinea	2036.94	284.25	1606.72	2723.49	25
Paraguay	6588.47	698.32	5807.24	8501.63	25
Peru	7619.61	2010.91	5184.97	11545.50	25
Philippines	4713.42	850.89	3796.61	6654.49	25
Thailand	10721.38	2466.95	6650.69	14976.00	25
Trinidad and Tobago	21922.51	8049.97	11976.30	31951.00	25
Tunisia	8127.98	1780.90	5614.94	10782.10	25
Turkey	14383.93	2685.15	10849.10	18992.80	25
Uruguay	13666.06	2880.07	9840.73	19827.70	25
Vietnam	3146.57	1195.86	1501.14	5370.21	25

Table C2
Descriptive Statistics CO_2 Per Capita

Country	*Average*	*Std*	*Min*	*Max*	*N*
Antigua and Barbuda	4.49	1.71	1.24	6.01	34
Cuba	2.83	0.46	2.21	3.48	34
Dominica	1.19	0.51	0.48	2.17	34
Dominican Republic	1.8	0.46	1.03	2.41	34
Grenada	1.57	0.7	0.53	2.87	34
Guyana	1.98	0.31	1.38	2.63	34
Haiti	0.16	0.04	0.03	0.25	34
Jamaica	3.28	0.68	1.92	4.33	34
St.Kitts and Nevis	3.42	1.46	1.18	5.19	34
Nicaragua	0.67	0.12	0.36	0.84	34
St. Vincent and the Grenadines	1.3	0.67	0.36	2.85	34
Donor pool					
Algeria	3.07	0.35	1.9	3.52	34
Angola	0.77	0.36	0.3	1.47	34
Argentina	3.86	0.41	3.29	4.68	34
Bahamas	7.28	5.69	4.29	37.93	34
Barbados	4.11	0.96	2.54	5.84	34
Bolivia	1.15	0.37	0.59	1.89	34
Chile	3.15	0.99	1.77	4.73	34
Colombia	1.57	0.14	1.28	1.89	34
Costa Rica	1.31	0.33	0.75	1.85	34
Ecuador	2.03	0.36	1.21	2.77	34
Fiji	1.17	0.36	0.59	1.94	34
Ghana	0.32	0.07	0.2	0.55	34
Guatemala	0.68	0.17	0.41	0.95	34
Indonesia	1.23	0.48	0.64	2.41	34
Jordan	3.2	0.38	2.07	3.94	34
St. Lucia	1.72	0.55	0.79	2.29	34
Malaysia	4.88	2.01	2.02	8.02	34
Malta	5.58	1.08	3.01	7.18	34
Mauritius	1.84	0.92	0.5	3.24	34
Nigeria	0.61	0.17	0.3	0.92	34
Panama	1.79	0.48	1.04	2.74	34
Papua New Guinea	0.6	0.12	0.43	0.95	34
Paraguay	0.64	0.15	0.4	0.88	34
Peru	1.23	0.29	0.89	1.96	34
Philippines	0.79	0.13	0.51	1	34
Thailand	2.56	1.28	0.76	4.54	34
Tunisia	1.95	0.35	1.41	2.62	34
Turkey	3.04	0.77	1.72	4.4	34
Uruguay	1.67	0.39	1.04	2.55	34
Vietnam	0.76	0.51	0.27	1.84	34

Table C3
Descriptive Statistics HDI

Country	*Average*	*Std*	*Min*	*Max*	*N*
Cuba	0.714	0.050	0.652	0.784	25
Dominican Republic	0.662	0.037	0.596	0.718	25
Guyana	0.602	0.029	0.537	0.638	25
Jamaica	0.694	0.026	0.651	0.729	25
Nicaragua	0.573	0.048	0.495	0.642	25
Haiti	0.446	0.026	0.405	0.49	25
Donor pool					
Argentina	0.771	0.037	0.705	0.826	25
Barbados	0.754	0.027	0.714	0.794	25
Benin	0.412	0.042	0.345	0.481	25
Bolivia	0.608	0.040	0.535	0.671	25
Brunei	0.825	0.024	0.782	0.864	25
Chile	0.773	0.045	0.700	0.845	25
Colombia	0.660	0.038	0.592	0.724	25
Costa Rica	0.715	0.036	0.653	0.775	25
Ecuador	0.684	0.027	0.643	0.739	25
Fiji	0.688	0.024	0.641	0.734	25
Ghana	0.505	0.040	0.455	0.576	25
Guatemala	0.555	0.047	0.478	0.637	25
Indonesia	0.611	0.049	0.528	0.686	25
Malaysia	0.723	0.043	0.643	0.787	25
Mali	0.323	0.070	0.222	0.438	25
Mauritania	0.450	0.038	0.378	0.513	25
Nepal	0.462	0.055	0.378	0.555	25
Panama	0.726	0.036	0.662	0.785	25
Papua New Guinea	0.439	0.047	0.360	0.515	25
Paraguay	0.636	0.033	0.580	0.692	25
Peru	0.678	0.039	0.613	0.737	25
Philippines	0.631	0.031	0.586	0.679	25
Thailand	0.662	0.052	0.574	0.738	25
Trinidad and Tobago	0.727	0.041	0.670	0.779	25
Tunisia	0.659	0.051	0.569	0.723	25
Turkey	0.666	0.061	0.576	0.764	25
Uruguay	0.746	0.032	0.692	0.794	25
Vietnam	0.588	0.063	0.477	0.678	25
Donor pool Haiti					
Benin	0.429	0.0330	0.375	0.481	19
Cameroon	0.464	0.027	0.433	0.514	19
Lesotho	0.458	0.019	0.437	0.495	19
Mali	0.350	0.057	0.261	0.438	19
Mauritania	0.466	0.026	0.429	0.513	19
Niger	0.290	0.037	0.237	0.351	19
Papua New Guinea	0.457	0.037	0.406	0.515	19
Senegal	0.423	0.039	0.372	0.491	19
Sudan	0.432	0.037	0.373	0.488	19
Tanzania	0.444	0.053	0.369	0.519	19
Uganda	0.430	0.047	0.336	0.488	19
Zimbabwe	0.441	0.031	0.406	0.507	19

Table C4
Descriptive Statistics Electricity Use

Country	*Average*	*Std*
Antigua and Barbuda	7.30	0.48
Cuba	6.98	0.12
Dominica	6.34	0.69
Dominican Republic	6.47	0.45
Grenada	6.54	0.73
Guyana	6.17	0.59
Haiti	3.66	0.37
Jamaica	7.08	0.50
St. Kitts and Nevis	7.37	0.55
Nicaragua	5.82	0.24
St. Vincent and the Grenadines	6.41	0.52
Donor pool		
Algeria	6.37	0.35
Angola	4.58	0.38
Argentina	7.45	0.30
Bahamas	8.33	0.19
Barbados	7.66	0.40
Bolivia	5.86	0.35
Chile	7.53	0.49
Colombia	6.75	0.15
Costa Rica	7.18	0.28
Ecuador	6.41	0.39
Fiji	6.48	0.22
Ghana	5.69	0.25
Guatemala	5.73	0.41
Indonesia	5.62	0.64
Jordan	6.95	0.45
Lucia	6.95	0.56
Malaysia	7.50	0.59
Malta	8.06	0.38
Mauritius	6.82	0.57
Nigeria	4.50	0.25
Panama	7.04	0.26
Papua New Guinea	5.94	0.14
Paraguay	6.46	0.48
Peru	6.51	0.29
Philippines	6.04	0.27
Thailand	6.88	0.68
Trinidad and Tobago	8.10	0.40
Tunisia	6.59	0.41
Turkey	7.10	0.53
Uruguay	7.40	0.35
Vietnam	5.38	1.02

Appendix D: Placebo Test

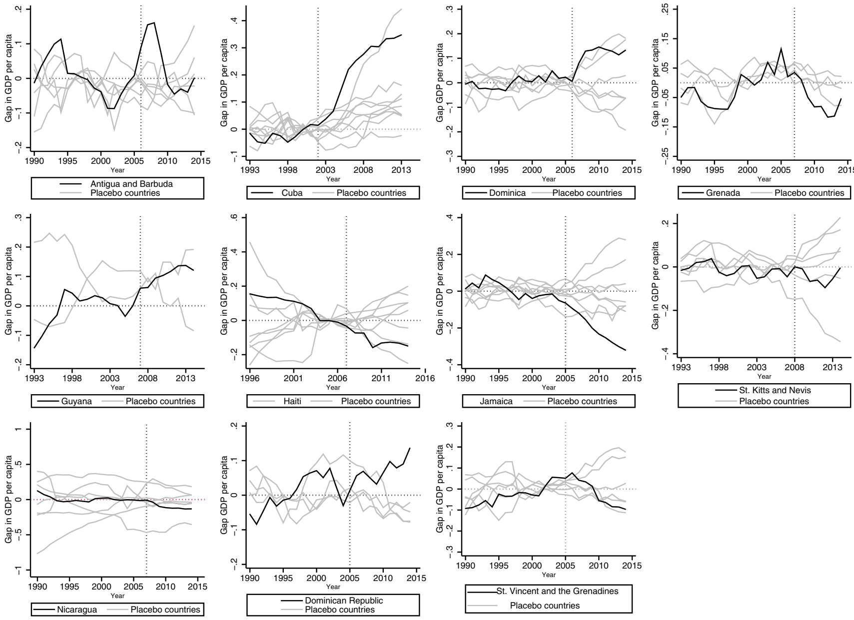

Fig. D1. Placebo test GDP per capita

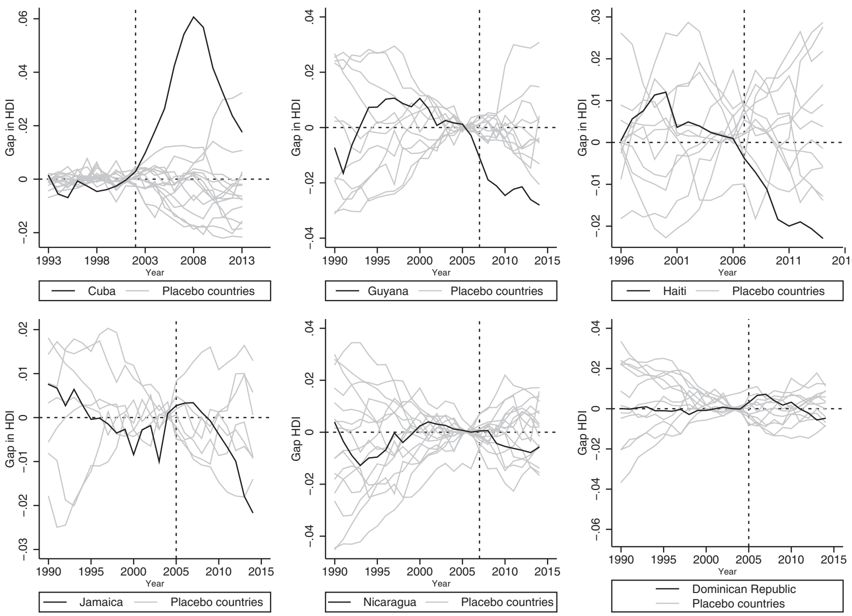

Fig. D2. Placebo test Human Development Index

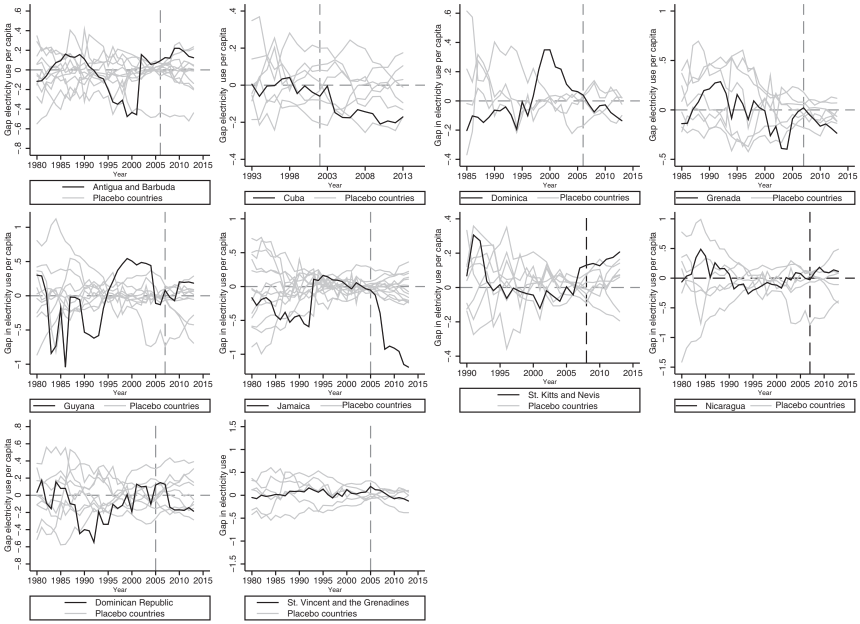

FIG. D3. Placebo test Electricity use per capita

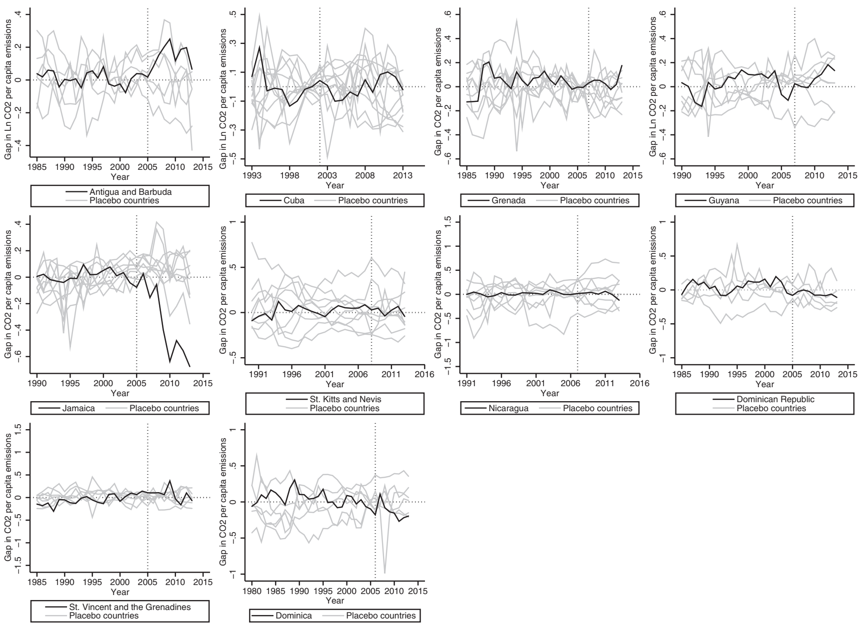

FIG. D4. Placebo test CO_2 per capita

Appendix E: Leave One Out

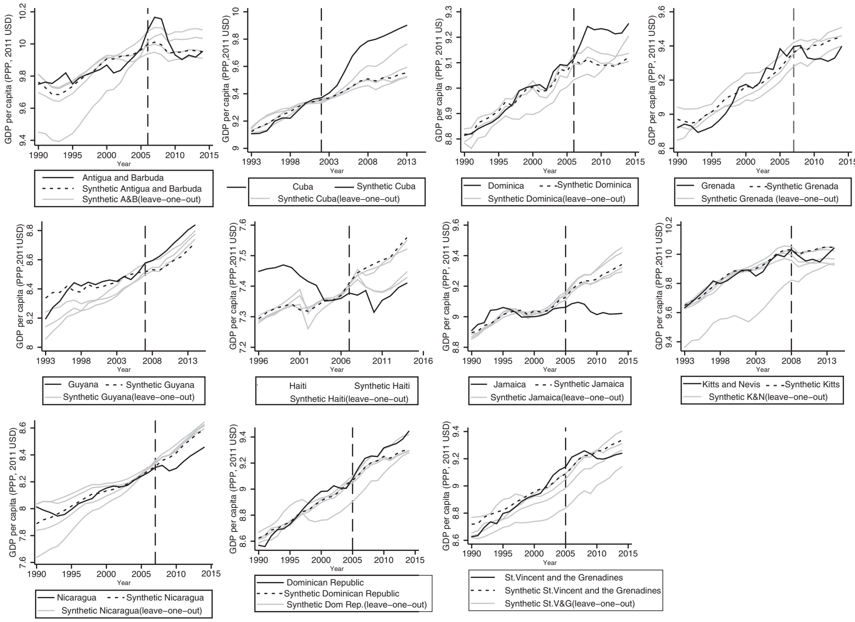

Fig. E1. Leave-one out GDP per capita

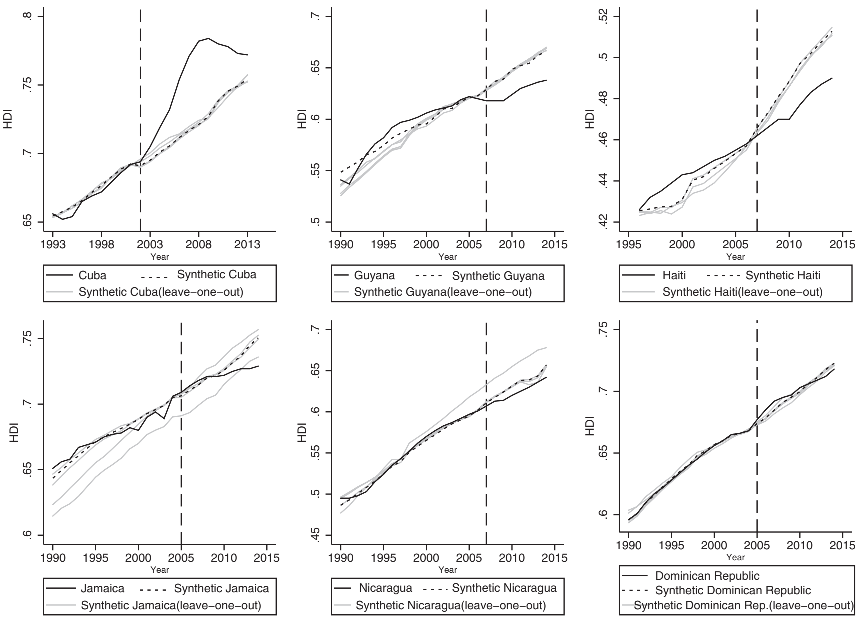

Fig. E2. Leave-one out Humand Develpment Index

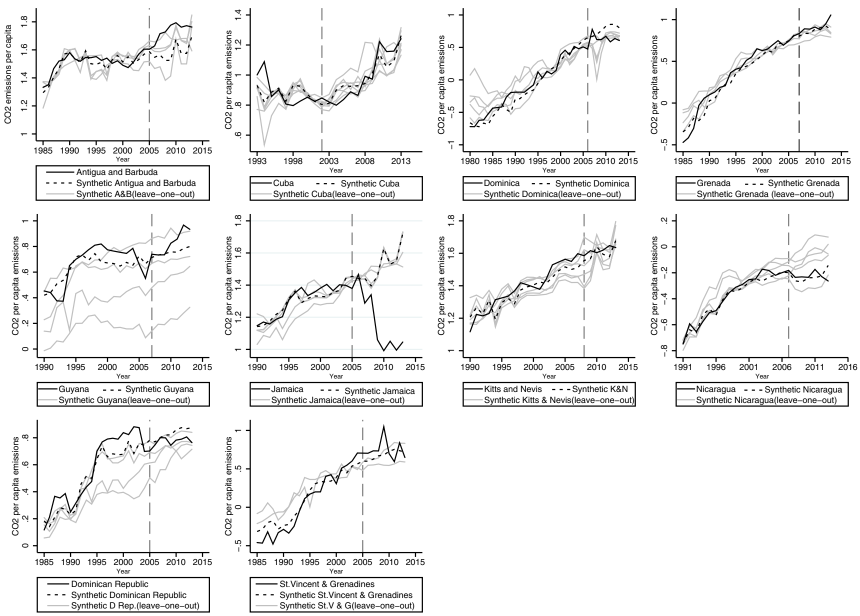

FIG. E3. Leave-one out CO_2 per capita

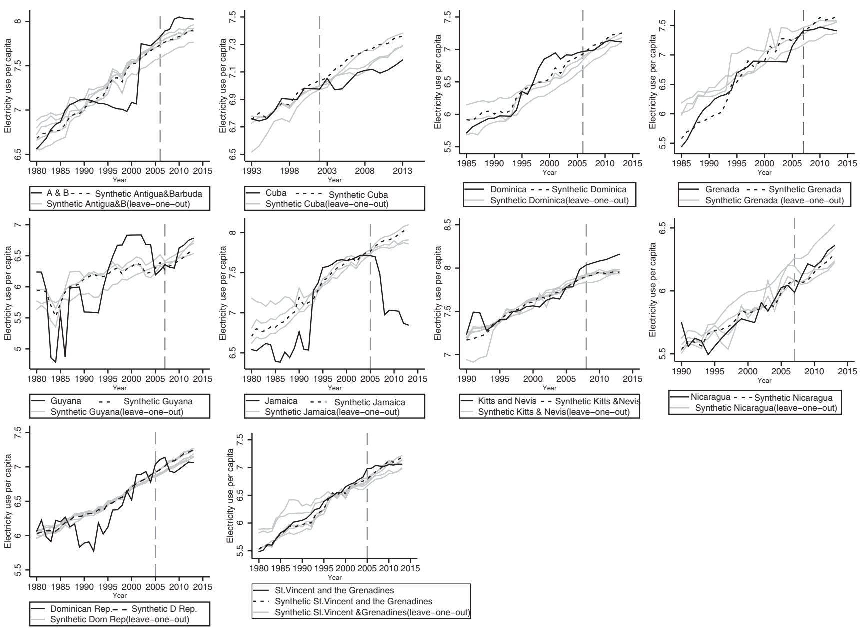

FIG. E4. Leave-one out electricity

Appendix F: Ratios

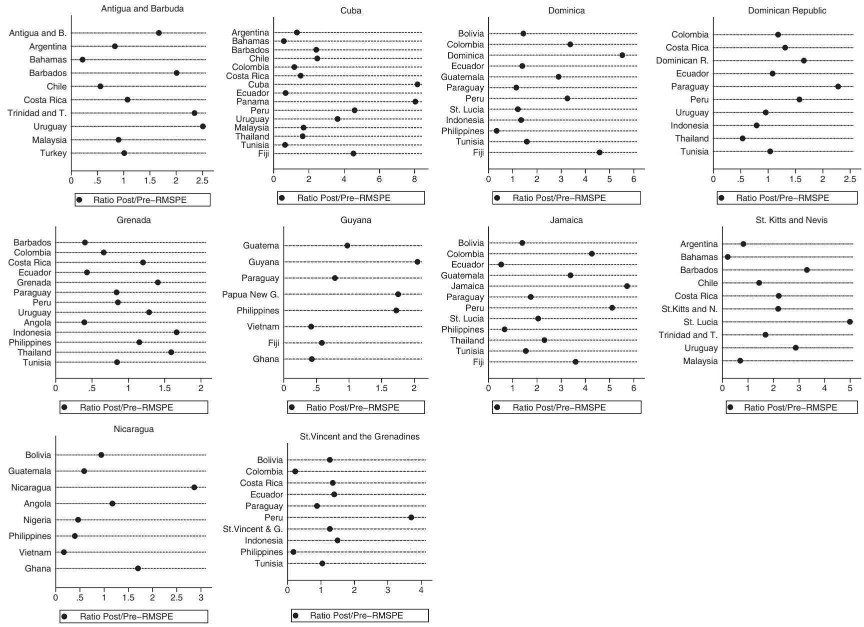

Fig. F1. Ratios GDP Per Capita

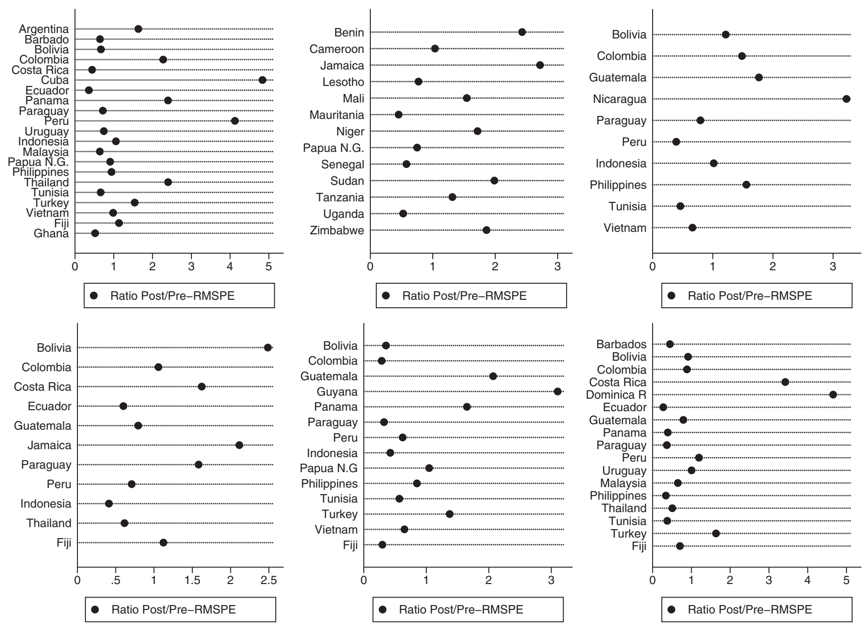

Fig. F2. Ratios HDI

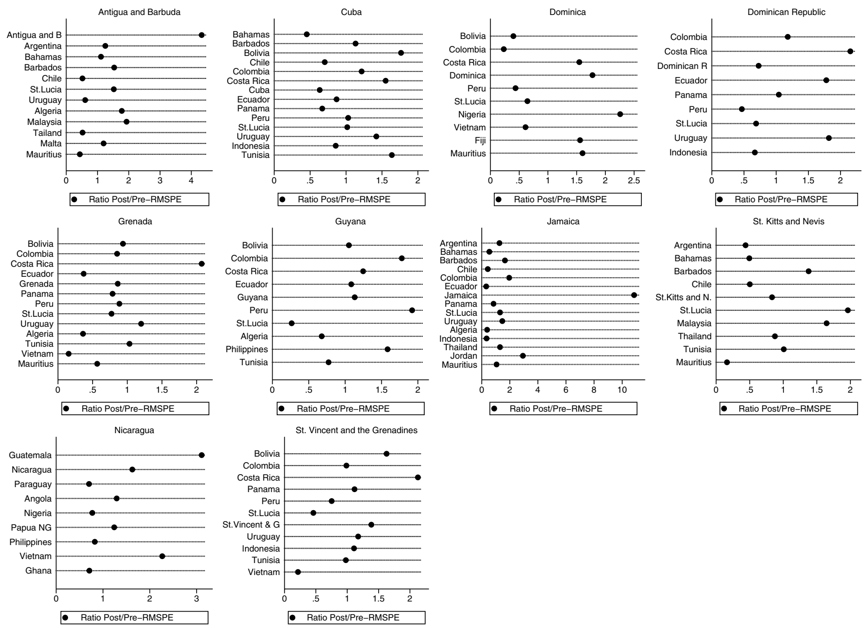

FIG. F3. Ratios CO_2 Per Capita Emissions

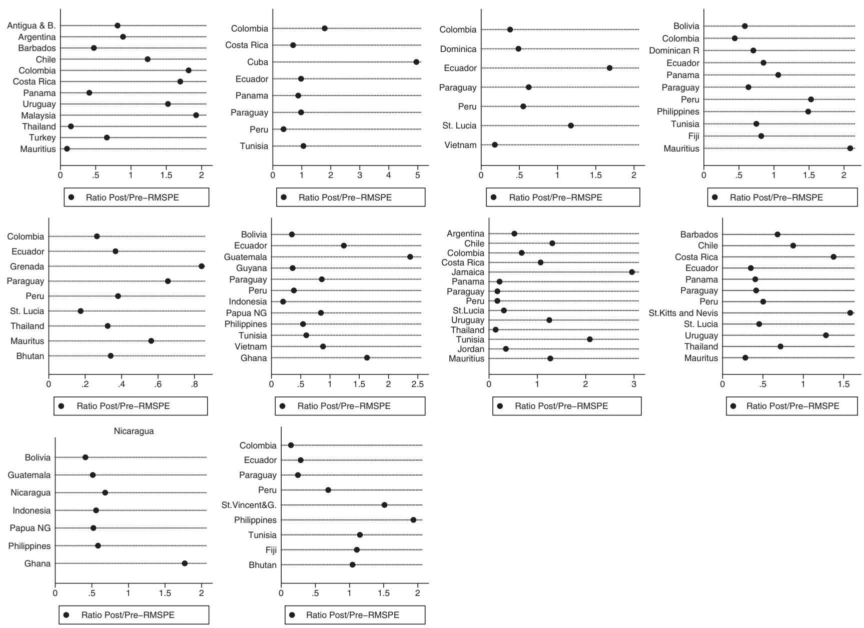

FIG. F4. Ratios Electricity Use Per Capita

Appendix G: Sources

Table G1
Sources

Variable	*Description*	*Source*
GDP per capita (PPP,2011 USD)	GDP per capita, purchasing power parity (constant 2011 international $)	
GDP per capita (2010, USD)	GDP per capita (constant 2010 US$)	
Trade openness	Sum of exports and imports of goods and services measured as a share of GDP	
Industry share	Industry, value added (%of GDP)	
Services share	Services, etc., value added (% of GDP)	
Agriculture share	Agriculture, value added (% of GDP)	World Development Indicators, 2016
Primary education	Gross enrollment ratio for primary school	
Secondary education	Gross enrollment ratio for secondary school	
Internet access	Individuals using the Internet (% of population)	
Urban population	Urban population (% of total)	
Inflation	Inflation, consumer prices (annual %)	
Carbon dioxide emissions	CO_2 emissions (metric tons per capita)	
Population growth	Annual population growth rate.	
Access electricity	Percentage of population with access to electricity	
Human Development Index	Summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living	United Nations Development Programme
Electricity consumption per capita	Total electric power consumption = total net electricity generation + electricity imports—electricity exports—electricity transmission and losses (EIA) by population (WDI). Excludes energy consumed by generating units	International Energy Statistics (EIA)

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